A time series analysis of household income inequality in Brazil 1977-2013

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Abstract

This paper analyses the evolution of household income inequality in Brazil from 1977 and
2013 using Brazilian National Household Survey data at aggregated and regional levels. Four
income shares quantiles are analyzed: Top 1%, Top 10%, Bottom 10% and Bottom 50%. The
novelty of our study is to use time series techniques to understand the phenomenon of income
inequality within this period. We use Markov-Switching Regime Change Model (Hamilton
[1989]) and State Space Unobservable Model (Harvey [1990]) techniques. Both strategies
suggest that income concentration periods are related to low growth rates but high inflation
rates as opposed to many developed countries (Piketty and Saez [2014]). Results from Markov-
switching models suggest a detection of a new regime during first decade of 2000’s in poorest
quantiles (bottom 10% and 50%) increasing their correspondent income shares. Moreover a
regime of low shares started to prevail at the same time for Top 10% whereas for those at
the Top 1% had prevailed a concentrated income share regime during eighties and nineties.
We argue that Brazilian macroeconomic instability helped to produce a regime of low income
shares at the bottom of the distribution. Our results suggest that recent inequality reduction
in the shares of top 1% quantile can be seen as a “back to normality” instead of “a new
era” whereas significant changes can be seen in other quantiles. State space models results
also suggests that macroeconomic of the eighties had a severe effects on Brazilian inequality
whereas the dynamics of Top 1% income shares reinforce the return of 70’s level considering
aggregated data. Last, our estimates unveil important regional differences in many quantiles
mainly on the low brackets where poorer regions seem to have persistent income-inequality
that take longer to be reduced.

JEL Codes: J50, J30

Key Words: evolution Income Inequality, time series analysis, public policies

Running Head: Household income inequality in Brazil: A time series approach.

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1 Introduction

Income inequality has shown a rising trend in some developed countries during last decades such as United States, Germany and Japan. Since Kuznets and Jenks [1953], many authors have documented the evolution of income and wealth for many developed economies (Lampman et al. [1962], Atkinson [2005], Piketty [2003], Atkinson and Piketty [2010], Alvaredo et al. [2013b], Piketty and Saez [2014], Piketty and Saez [2014], Soltow [1989], Piketty [2010]).

On the other hand Brazil experienced an opposite trend with persistent decline in inequality during this period. Although this income inequality trend is documented for Brazilian aggregate data, the literature is silent on the patterns of income concentration in different income brackets in Brazil and regions. A better understanding of these differences is important not only to policy formulation but also to unveil issues that cannot be addressed by only looking at aggregate data. The debate on income inequality in Brazil has grown in the last decade, mainly due to changes in economic, political and social environment over the past 40 years of its history. During seventies Brazilian economy faced a period of economic prosperity with many people evolving to middle class standards. The second round of oil prices increases in late seventies had a decisively negative impact on Brazilian growth. During the eighties Brazilian economy faced economic downturn, hyperinflation and bailouts.\footnote{Cline [1995] reviews Latin America debt crisis events dealing with Brazilian debt crisis.} Analysts name this period as “lost decade”. The patterns of income distribution was drastically affected by economic environment in all regions and social levels.

During the nineties Brazilian officials managed to stabilize macroeconomic indicators by adopting reforms that lead to inflation reduction and moderate growth. Macroeconomic stabilization helped to recover purchasing power and income of individuals and households. The effects were particularly important to poorest ones. They were not able to protect themselves against deleterious effects of inflation on their income and wealth accordingly. The twenty-first century began with commodities prices boom and Brazil is a great exporter of many commodities such as soybean, coffee, iron ore among others. Brazilian Federal government also launched many programs that aimed to reduce poverty by using direct income transfers.

This paper aims to construct and analyze the patterns of income distribution for Brazil (and regions) in different quantiles. The period of our sample goes from 1977 to 2013. Times series are constructed of income concentration for four income brackets (Top 1%, Top 10%, Bottom 10% and Bottom 50%) for Brazil and all five regions using National Household Survey (PNAD), collected by the Brazilian Institute of Geography and Statistics (IBGE)\footnote{Unfortunately, this survey does not allows to build time series of wealth inequality in Brazil.}. We investigated the existence of different regimes in those series by using rigorous and modern time series techniques. Two
methodologies are used: (i) a Markov-switching methodology developed in Hamilton [1989] and (ii) Structural time series techniques developed in Harvey [1990].

Our results detect a new regime in years of 2000's of high income shares in poorest quantiles for aggregated data and some regions, suggesting an improvement in income distribution for those individuals. For Top 1% quantile a regime of high income shares had prevailed during eighties and nineties. Recently, we find a change in the regime to low income shares similar to the one prevailing at the beginning of our sample suggesting that the contribution of these quantiles to reduce inequality in recent years can be seen as a “back to normality” instead of “a new era”.

Our second strategy, state space models also suggests that macroeconomic of the eighties had a severe effects on Brazilian inequality whereas the dynamics of Top 1% income share reinforce the return to previous stages of income concentration. Our strategy reveals another phenomenon that might explain income concentration: high levels of inflation. This result contrasts with most of the empirical literature for developed countries that argues for growth as the main reason for income concentration. Noteworthy, our estimates unveil important regional differences in many quantiles, mainly on the bottom brackets where poorer regions seem to take longer to decrease inequality compared to richer in Brazil.

This paper is organized in five section including this introduction. In the second section a literature review on income inequality in Brazil is done. In the third section dataset is presented and the econometric methodology is discussed. In the fourth section the results of two econometric exercises are reported and discussed. Finally some final remarks are drawn.

2 Motivation

Many factors can affect the dynamics of income inequality. Brazil has many interest features over recent past that turn the country an interesting case to be studied on the topic of income distribution. Brazil has a past of chronic inflation in 70’s and 80’s. Particularly in 80’s, Brazil suffered with macroeconomic imbalances, unprecedented, even for Brazilian standards, level of inflation, public deficits and bailouts. From 94 onward up to 2010, Brazil faced a period of unprecedented macroeconomic stability. The country is also facing a rapid demographic transition. During the 2000’s a policy of direct income transfers to the poor was launched and important change in the labor market took place as well. A rigorous investigation of time trends in Brazilian data is important to unveil these trends and to detect when all aforementioned factors turned into a positive or negative trend on income inequality. Particularly how the richest and poorest one were affected by these trends.
2.1 Why using a time series approach to deal with income inequality data is important?

Data on income inequality over a long time span is becoming available for many countries. Although it is important to understand the factors driving the changes of income inequality from two points in time for one country, detection of new trends and structural change in one country data and common trends among countries, regions or income share quantiles are also important to obtain a comprehensive view of the phenomenon. Since the eighties a revolution in time series techniques allows analysts to analyze non-stationary data and detect changes in trends and structural change.\(^3\)

The use of time series techniques to address possible income inequality trends has been tried many times in the literature. One of the first studies is Blinder and Esaki [1978]. They used time series data and tried to assess the importance of unemployment and inflation on income inequality. In their regressions, the hypothesis of the existence of a time trend and structural change were also investigated. Although their results may be challenged using recent advances in time series field, they found evidence in favor of the hypothesis that unemployment cause a negative and significant impact on income inequality but not inflation. If inflation had any impact it would be a positive one.

Another possible approach to deal with income inequality data using time series data is to investigate the time series proprieties of the series using univariate analysis without explanatory variables. This is the approach used in our paper. Raj and Slottje [1994] opts to univariate analyses. They ran Zivot and Andrews [1992] test to investigate the existence of a unit root, a possible (broken) time trend in the data of income inequality. They investigated different measures of income inequality and claimed that the series are better described as a stationary process around a broken trend compared to first different stationary process. The period investigated by the authors goes from 1947 to 1990 for United States. Their results suggests a break in the trend occurred around 1965. After that point a positive trend in inequality could be detected.

The unit root tests have a well known power problem if the data generator process contains a high level of persistence. A longer time series is required to circumvent this problem. Roine and Waldenström [2011] works with a secular and comparable dataset for a group of developed countries. They use data that covers the period of Great Depression in the thirties, Second World War and Post-War period. The longest series starts in 1900 and ends in 2005 for Japan. They use the method developed by Bai and Perron [1998, 2003] to investigate the existence of multiple changes in data generator process. Particularly they are interested in investigating the existence

\(^3\) Maddala and Kim [1998], Pesaran [2015] contain rigorous discussion of these developments.
and possible structural changes in time trends. The paper do not focus only on aggregated data but also analysis time evolution of different quantiles similar to the approach of our paper. They also investigated whether or not countries share the same trends. They were able to find a new upward trend around 60’s and 70’s for Anglo-Saxon countries.

2.2 Background on Brazilian Income Inequality

The dynamics of income inequality has gained attention recently due to a rising trend of that has been observed in developed countries. After the Great Depression when the income inequality raised, the world had started to observe a falling trend in income inequality throughout following decades until the seventies. In eighties a rising trend was observed again and nowadays the level of income inequality is equivalent to the pre-crisis period of 1929. 
Piketty and Saez [2006a] highlights that this trend is not restricted to United States. Other developed countries like Canada, United Kingdom are showing similar pattern. France seems to be an exception. After the fall during the 40’s, income inequality is virtually stable since then. Tachibanaki [2006] report a similar pattern to Japan.

Piketty and Atkinson [2007] studied income inequality pattern for continental Europe and English native-speaking countries during the twentieth century. Alvaredo et al. [2013a] expanded the analysis to 22 countries from Asia, Europe, Oceania, North America and South America. Piketty [2014] states that growing income inequality after eighties was due to the increase in the share of labor income contrasting with what happened in the 1929 pre-crisis period when inequality was largely due to capital income, such as profits, dividends and rents.

In Brazil the topic of income distribution also gained great importance in recent years, both in academic field and political arena. After important economic and social changes, the structure of income distribution in Brazil has undergone significant changes. Langoni [2005] calls attention to the level of income inequality on Brazilian income distribution. He highlighted that a widening inequality process was taking place by comparing 1900 to 1970 data. Hoffmann [1973] analyzes income distribution patterns during the decade of 60’s and seeks to relate it to minimum wage policy changes, showing that the parameter linking degree of inequality to minimum wage was negative and statistically different from zero.4 They found a strong evidence of raising the concentration of income and wealth in the country during seventies and eighties.

Lacerda [1994] confirms the rising trend of income distribution during the eighties, specially in the second half of the decade. Brazilian indicators were quite above the values of most countries

4Hoffmann and Kageyama [1985] analyses the income distribution and its time evolution since the mid-1970s, when a series of indicators started to be released. The main example is National Household Survey (PNAD) collected by IBGE. IBGE is the Brazilian Institute of Geography and Statistics.
around the world. (Table 1) According to him, the main reasons for this behavior was the high inflation that lasted almost two decades in Brazil and the successive failed attempts to stabilize macroeconomic indicators and wage policies.

Looking at the data of twentieth first century, Hoffmann and Ney [2008] analyzes the fall in income inequality in early years of this century by analyzing National Household Survey data from 1995 to 2006. They focus the analysis on important states of Brazil such as São Paulo, Minas Gerais and Rio de Janeiro. Soares et al. [2006] had also got to the same conclusion, stating that inequality in Brazil began to fall before 2006, mainly due to the decrease shares retained by people at highest quantiles.

One shortcome of PNAD survey is that income data of upper quantiles may be underestimated. Households are asked to provide their level of income. Medeiros et al. [2015] uses income data collected by Brazilian Federal Revenue Agency which is a more accurate source of information. and combines this dataset with PNAD. He argues that earned income is underestimated at higher decils. Therefore, probably our inequality estimates calculated from PNAD may be underestimated (see also Hoffmann [1988] and Barros et al. [2007c]) but we build a time series of informed income

<table>
<thead>
<tr>
<th>Country</th>
<th>Share</th>
<th>Year</th>
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<tbody>
<tr>
<td>Brazil</td>
<td>53.2</td>
<td>1989</td>
</tr>
<tr>
<td>Colombia</td>
<td>35.8</td>
<td>1988</td>
</tr>
<tr>
<td>Pakistan</td>
<td>31.3</td>
<td>1985</td>
</tr>
<tr>
<td>Swiss</td>
<td>29.8</td>
<td>1982</td>
</tr>
<tr>
<td>India</td>
<td>26.7</td>
<td>1983</td>
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<tr>
<td>France</td>
<td>25.5</td>
<td>1979</td>
</tr>
<tr>
<td>Italy</td>
<td>25.3</td>
<td>1986</td>
</tr>
<tr>
<td>United States</td>
<td>25.0</td>
<td>1985</td>
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<tr>
<td>Bangladesh</td>
<td>24.5</td>
<td>1982</td>
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<tr>
<td>Germany</td>
<td>23.4</td>
<td>1984</td>
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<tr>
<td>Japan</td>
<td>22.4</td>
<td>1979</td>
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<tr>
<td>Belgium</td>
<td>21.5</td>
<td>1979</td>
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<tr>
<td>Sweden</td>
<td>20.8</td>
<td>1981</td>
</tr>
</tbody>
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Table 1: Brazilian and Selected Countries Income Inequality.
and assuming that underestimation does not change overtime, which seems reasonable in Brazil, our procedure still allows us to compare the evolution of income concentration overtime. Our Figure 1 illustrates income distribution in our sample. We detail its evolution below.

2.2.1 Poorest 10% household quantile

The income share of Brazilian poorest 10% households in 2013 was 1.2% of the total income of the country. The highest value in our sample was 1.3%. This share remained almost stable from 2003 onward. This result suggests that this quantile played a secondary role in the observed reduction in Brazilian inequality after the end of the sample. Income shares rose substantially when data from 2000 is compared to the level of the beginning of the sample up to early years of the nineties. The lowest level of this share was 0.7% in 1989 when Brazilian inflation had a peak of almost 90% per month in consumer price index.

The picture for regions are not much different from aggregated data. South and Southeast regions are those that have highest income shares for lowest 10% quantile. Income shares are 1.6% and 1.4%, respectively and these regions showed a considerable improvement in recent years.

In 1990 the income share was 0.9% in the South and 0.8% in the Southeast, with increasing rates from the end of the decade of 1990. For Midwest region the income share was 1.3% in 2013 to the 10% poorest households.

Two regions have means below Brazilian average: North and Northeast, with 1.1% and 0.9% respectively. There was an improvement of the share for North in the beginning of the 1990s rising from 0.9% in 1990 to 1.7% in 2005, the highest among all regions. After that North region started to have a decline in income share. The picture for Northeast is quite different. Indicator remained stable from the late nineties up to the end of the sample and below national average.

There was a rising trend in shares of South and Southeast regions since middle nineties, accounting for 1.6% and 1.4%, respectively. The number for these shares in 1990 were 0.9% in the South and 0.8% in the Southeast. Midwest regional data also showed an improvement in income shares retained by the poorest ones probably due a better economic performance and agricultural development of the region.

Northeast continues to be the region where most of Brazilian poverty is located. According to PNAD data 43.1% of the poorest ones lived in Northeast in 2013. But there have been improvements in recent years. For example in 1977 Northeast had 65.9% of poorest ones. One possible explanation for the change has to do with successful macroeconomic stabilization program launched

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5 Households data are protected by banking secrecy law and this restricts the access to these data. Brazilian Federal Revenue Agency unfortunately does not allow ample access for academic community.
in 1994 - Real Plan. Inflation rates dropped substantially and level of inflation tax collection was dramatically reduced. Since the poorest did not have proper tools to protect their income against inflation, macroeconomic stabilization helped a lot to maintain their income shares.

2.2.2 Poorest 50% Households

Brazilian 50% poorest households had earned 17.5% of total income in 2013. Since middle of nineties there has been a upward trend in these shares. Similar pattern can be observed in regional data as well. After a period of downward trend in the eighties and yearly nineties, the share of 50% poorest ones starts to rise faster after 2000. All regions have shown similar improvements. This indicator seems to capture in a more direct measure, that income distribution towards the poor occurred in the late 90’s.

2.2.3 Top 10% Income Households

Figure 1 shows a clear downward trend in income share of Top 10% households. This downward trend started in middle of nineties and became stronger during the first decade of 2000. All regions seem to share similar patterns during this period. Two peaks can be observed in Brazilian aggregate data: These are 1977 and 1989. In 1989 Brazil had faced the highest inflation level of its history (1,972,918%). As already mentioned the poorest did not have access to financial tools that could allow them to protect their income against inflation. It is not a coincide that year of 1989 can be classified as positive peak. This figure suggests that redistribution occurred involving Top 10% income households and Bottom 50% individuals.

2.2.4 Top 1% Income Households

The picture obtained from Top 1% quantile is slightly different from Top 10%. There is also a downward trend in the share of this group much less pronounced as Top 10% group. The figures of all regions look quite similar except the data from Midwest region during the eighties. Southeast is the region where most of the Top 1% households are located, which suggests that those individuals at the top quantile present the most persistent income share in our sample, around 15%.

2.3 Macroeconomic factors affecting income inequality

This paper focus on aggregate measures of income inequality and therefore it seems natural to address macroeconomic policies experienced in this period to understand the fluctuations of the income inequality series. The main reasons for the improvement on income distribution pattern in Brazil has to do with macroeconomic stabilization, economic growth, falling unemployment,
Source: Primary data comes from PNAD Survey.
Developed by the authors.

Figure 1: Brazilian Income shares - National and Regional data.
education investment, income-transfer policies, trade and financial openness. A lot of research has been done to investigate which of these factors had played a major role in explaining income distribution patterns. As we cannot claim any causality out of our results we discuss below the evolution of one macroeconomic variables that could have affected income concentration in our period.

Minimal wage policy aims to adjust wages in a federal formula to compensate inflation. During the period of macroeconomic instability in the eighties and first half of nineties, this policy had a downward trend in real terms can be clearly observed. After macroeconomic stabilization during 93-97, the volatility of minimum wage purchasing power has dramatically reduced. A policy to recover the purchasing power of minimum wage was launched from that period onward. These trends can be clearly seen in Figure 2 where the value of the minimum wage deflated by Brazilian Consumer price index is plotted.

Minimum wage in Brazil does not affect only the private sector. Income transfers from municipalities to federal government, social security transfers such as government unemployment insurance program, retirement earnings are also indexed to minimum wage. Aforementioned policy to raise minimum wage may have had an important effect on income distribution particularly in poorest quantiles. Firpo and Reis [2007] presents evidence that minimum wages increases during 2001 to 2005 had positive impact on reduction of income inequality.

Brazil had also showed an upward trend in college attendance and average schooling-years has risen in late nineties and lasts up to end of our sample. These changes may have affected income distribution by allowing higher earning from Brazilian middle class. Barros et al. [2006] finds evidence of a a growing number of more educated workers accessing labor markets. This helps to explain part of income inequality reduction during the period.

Federal Government launched a series of direct income transfers to the poor people in order to reduce poverty and improve education attendance of the children starting in early 90’s but had became a considerable program in the early 2000 (Bolsa Familia). The program seems to be efficient in helping to reduce extreme poverty in many regions in Brazil.

Macroeconomic stabilization Plan named as “Plano Real” started in the end of 1994 along with the introduction of pro market reforms. Brazil adopted in 1999 inflation targeting, dirty floating exchange rate regime and a fiscal consolidation plan reducing public deficits to manageable levels and reducing the public debt as share of GDP as well. As a result of macroeconomic stabilization, Brazilian economy started to show moderate per capita growth, low inflation. Macroeconomic

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6Barros et al. [2006] summarizes this literature

7Barros et al. [2007a] estimate that these transfers can explain about half of all inequality reduction from 2001 up 2005.
Source: IPEADATA - IPEA (Applied Economic Research Institute)

Figure 2: Real Minimum Wage in Brazil - Deflated by Consumer Price Index

Source: IPEA

Figure 3: Enrollment Level and Brazilian 50% poorest quantile income share
stabilization allows Brazilian economy to operate with unprecedented low level of inflation in almost a century. Since income of poor households were severely impacted by inflation, stability on this index also helped a lot to explain income distribution patterns after that. The poorest ones did have access to financial tools to protect their income and wealth from deleterious effects of inflation. This macroeconomic recovery helped to reduce poverty and had positive impacts on income distribution.\textsuperscript{8} Cysne et al. [2005] develops a formal model linking inflation and different access to financial assets to income inequality patterns.

Unfortunately, our empirical strategy does not allow us to pin down which are the elements more relevant nor the specific impact of each of those. Nevertheless, we are able to precisely capture the timing of a regime/trend in Brazilian income concentration.

3 Dataset and Econometric Methodology

The goal of the study is to analyze evolution of income distribution among households, focusing on participation of 1\% and 10\% percent richest and 10\% and 50\% poorest quantiles for aggregated and regional data. Our sample will cover the period from 1977-2013 period from Brazilian aggregated and regions (North, Northeast, South, Southeast and Midwest). It covers 37 years of Brazilian History on the subject. We build this data using the first released household survey in Brazil (1977) up to the most recent.

3.1 Dataset

PNAD was firstly released in 1967 by IBGE, on a quarterly basis, but with a restricted geographical coverage. This format lasted with minor changes until 1973 when its geographic coverage was expanded. At that time PNAD became the most comprehensive survey in Brazil. During the year of the Census, PNAD is not collected. The survey was not collected in 1974 and 1975. After 1976 the survey was reformulated and the frequency changed to annual.

Questionnaire of PNAD survey continued to suffer major changes up to the year 1979. After that the structure of the survey suffered minor changes over time. Geographical coverage has remained unchanged up to 2004. The residential areas of rural Northern region of Brazil entered the survey and minor changes in questionnaire and indicators definitions occurred in the period, but without compromising data compatibility.

Another drawback with the survey is that income obtained from real states and investment such as rents, interest rate and dividends are often poorly recorded, underestimating income shares for

\textsuperscript{8}See Barros et al. [2015] for evidence on inflation control and its impact on poverty and inequality reduction.
the highest quantiles of society. This issue was raised by Hurst et al. [2014].

Although aforementioned problems persists, PNAD Survey has proved to well describe trends exhibited by household income distribution and continues to help Brazilian government and scholars to access the results of income distribution policies among other issues.

The data for this study comes from PNAD micro data from 1977 to 2013, except for the census years when there was no survey. IBGE did not collect data in 1994. In order to deal with this data deficiency, we performed a reconstruction of the series to fill missing data points. We opt to use unobserved component methodology. By using a state-space model adapted to the case where sample contains missing data we can obtain estimates of missing points. The procedure is available at Oxmetrics 7.0 software and details can be found in STAMP package documentation. Reconstruction of the series does not change the actual values obtained from the data of PNAD but only add estimates for missing values.\footnote{Our results are not sensitive to those assumptions are available upon request.}

PNAD survey allows us to identify individuals, family and household as well. We disregarded all individuals that did not answer questions about income. The remainder data is used even if the answer of the individual was zero to income level question (non-income at all).

3.2 Econometric Methodology:

3.2.1 Markov Switching Model

Markov regime switching models are non-linear class models of time series analysis in which there is a probability of transition between regimes connected to the immediately preceding period. These models are very useful in modeling series that present periods with distinct behaviors. For example, one should not expect a recessionary economy to behave in the same way as an economy in a period of expansion. This non-linearity in economic series can be modeled from regime-switching models. We will use a Markov-switching autoregressive model, allowing three regimes. The estimated model will have the following form:

$$ y_t = c_k + \phi_k y_{t-1} + \varepsilon_{1t} \quad if \quad s_t = k $$ (1)

where $s_t$ takes values $k \in \{1,2,3\}$.

We can define a set of transition probabilities between regimes defined: $p_{ij}$. This probability can be defined as the probability of the regime $i$ being followed by the regime $j$. The phenomenon is governed by a non-observed Markov chain process in which the probabilities model the transition
from one conditional function to another. The model estimation process depends on the construction of a likelihood function, and its optimization using an algorithm similar to that suggested by Hamilton (1989). First, the likelihood function is optimized, next the filtered and smoothed probabilities are calculated, and finally standard deviations and statistics are calculated for inference. All Markov switching models were estimated in Oxmetrics 7.0.

### 3.2.2 Structural times series models

According to Watson and Engle [1983], the use of unobservable variables in Economics is widely accepted as a useful approach to describe economic phenomena. The general idea of the structural model for time series is that the series are a sum of components, not necessarily observed, such as trend, seasonality, and cycles, wherein each component evolves according to a particular dynamic. Structural models in a state-space representations offer a very interesting approach to forecasting. One can define a state-space model as follows:

\[
y_t = Z_t \alpha_t + \varepsilon_t \quad \varepsilon_t \sim N(0, H_t)
\]  

(2)

\[
\alpha_{t+1} = T_t \alpha_t + R_t \eta_t \quad \eta_t \sim N(0, Q_t)
\]  

(3)

where \(y_t\) is a vector of observations \(p \times 1\); \(\alpha_t\) is called the state vector, is unobserved, and has dimension \(m \times 1\); \(\varepsilon_t\) and \(\eta_t\) are independent error terms. The model estimation is done using the Kalman filter combined with maximum likelihood, in which the forecast errors are minimized. The Kalman filter is composed by a set of equations to estimate recursively in time the mean and conditional variance of the state vector. De Rossi et al. [2006, 2009] discuss how to use state space model to model the dynamics of different quantiles.

The estimated state-space structural model was decomposed into trend \((\mu_t)\) and an autoregressive component \((\psi_t)\). All models were estimated using STAMP from Oxmetrics 7.0. Thus, model configuration follows the form of the basic structural model with an autoregressive component, which can be written as follows:

\[
y_t = \mu_t + \gamma_t + \varepsilon_t \quad \varepsilon_t \sim N(0, \sigma^2)
\]  

(4)
\[ \mu_{t+1} = \mu_t + \beta_t + v_t \quad v_t \sim N(0, \sigma_v^2) \] (5)

\[ \beta_{t+1} = \beta_t + \eta_t \quad \eta_t \sim N(0, \sigma_\eta^2) \] (6)

\[ \psi_{t+1} = \rho \psi_t + \xi_t \quad \xi_t \sim N(0, \sigma_\xi^2) \] (7)

4 Results

This section is divided in two parts. The first part focuses on results obtained from Markov Switching Time Series Models while the second part focuses on the results of State Space Models. We performed both exercises for Top 1%, Top 10%, Bottom 10%, Bottom 50% quantiles using aggregated and regional disaggregated data. The goal is to investigate whether there is evidence of changing pattern in income distribution in Brazilian regions and when it occurred. The descriptive analysis of the previous sections suggested that there was a significant change in income distribution pattern in the first decade of 2000 towards more equality.

4.1 Markov Switching Models

We estimate a Markov switching autoregressive model in order to better understand the dynamics of quantile income shares for Brazilian aggregated and disaggregated data. We opt to work with at most three different regimes of income shares (high, intermediate and low). Models are estimated for Bottom 10%, Bottom 50%, Top 10% and Top 1% income shares quantile. Figures 4 and 5 show estimates of which regime is the most likely to have prevailed in each point of time. Estimates of regime alternate in time and are not erratic if income share is at one regime in one period then it tends to stay in this regime next period.

4.1.1 Brazilian data

Firstly we analyze Brazilian aggregated data. For the Bottom 10% quantile data (first graph of Figure 4) there is a clear evidence of three regimes during the sample period: low, intermediate and high income shares. Intermediate share regime prevailed from the beginning of the sample (1977)
up to the middle eighties. This regime was followed by low income shares regime from middle of the eighties up to 1998. Then from 1998 up to 2003, income shares had entered in the intermediate regime again. From 2003 up to end of the sample the high income shares prevailed.

For the 50% poorest quantile it is possible to tell a different history. One regime lasts from the beginning of the sample up to 2002. This regime has the lowest mean. From 2002 up to 2006, a second regime prevailed. From that point up to the end of sample a third regime took place. The third regime is clearly a high income share regime whereas the second seems to be a transition from a low to high income share regime. This suggests that inflationary crisis of the eighties had severe effects on income share of poorest ones but not that severe on the 50% quantile.

Finally for Top 10% quantile there is an intermediate regime prevailing in almost all points from beginning of the sample up to 2002. After that a regime of low income shares started to prevail. There is also a third regime associated with positive peaks of income shares in the beginning of the sample and at end of eighties when Brazilian economy was facing a unprecedented inflation crisis. It is reasonable to conclude there was a transition from a higher level of income share to a lower income share about the year of 2003 for Top 10% quantiles.

As a stylized fact there is a clear evidence in favor of a transition towards a more equal income distribution pattern in Brazilian data. This movement started with poorest ones in late nineties probably due to changes in macroeconomic environment and got stronger during the first decade of 2000 when it was possible to observe regime changes in all quantiles.

4.1.2 North region

We start our analysis with the results of 10% poorest quantile in North region. Clearly we can detect three regimes. The first one is an intermediate shares regime that lasts from seventies up to middle eighties. From that time up to 2000, a regime of low income share prevailed probably as a consequence of macroeconomic instability of the economy. But from that period up to the end of the sample, two regimes alternates, one with high income shares and other with intermediate income shares. This regional picture contrasts with national one where the regime of high income shares tended to prevailed in the same period. Particularly high income shares regime was followed by an intermediate one during 2008 when Brazilian growth was reduced due to the consequences of financial crisis that happened in United States. After 2010, the growth of Brazilian economy started to reduce and this is the point where intermediate regime succeed high income shares regime.

For the 50% poorest there is evidence of three distinct regimes. Bottom income shares prevailed during late eighties up to 2002. Then a transition to an intermediate income shares occurred. Finally
from 2004 up to the end of the sample a regime of high income shares tended to prevail. For Top 10% quantile, two regimes prevailed in almost all points. The first one is a high income shares regime prevailing from middle eighties up to 2002 whereas a low income shares regime prevailed from that point up to the end of the sample.

### 4.1.3 Northeast region

Now we look at the results of Northeast region. The pattern of income shares for poorest 10% contrasts with aggregated Brazilian results for the same group. The best period in terms of income shares prevailed in the beginning of the sample up to the middle of the eighties. Then a regime of low income share has prevailed up to 1998. For that point up to the end of the sample a regime with intermediate income shares started to prevail. The conclusion is that macroeconomic crisis of eighties could have caused a drop in this income shares quantile and there was no fully recovery up to end of our dataset.

The picture for 50% poorest quantile differs from aggregated data. Share during macroeconomic instability period of the eighties were negatively affected but there was a full recovery during the end of the nineties and an improvement from 2002 up to end of the sample. The transition to a better position seems to had started early than national data for this quantile.

### 4.1.4 Midwest region

It has become one of the most important regions for agricultural production particularly those related to exports. Our estimates for Low 10% suggests that there is evidence of three regimes. The regime of high income shares prevailed in yearly eighties and late seventies and after 2002. During the late eighties a regime of low income shares prevailed and it was followed by a intermediate income share regime. This regime was followed by high income shares regime. High income shares regime that was prevailing in the end of the sample can not be seem as a new one since it had already prevailed in the eighties.

For the 50% poorest quantile, there is a regime of intermediate income shares that prevailed in most of the period from beginning of the sample up to 2002. Only during the late eighties, a regime of low income shares was active. Finally from 2002 up to the end of the sample, a regime of high shares started to prevail.

For Top 10% low and intermediate income shares regimes prevailed during most of the sample. During late eighties a regime of high income shares had prevailed. At the end of the sample a regime of low income shares seemed to be prevailing but it cannot be seen as new regime since it had also prevailed during the eighties as well.
4.1.5 South region

For South region data, there is a clear pattern indicating that something new was going on from 2002 up to end of the sample. In the end of the sample a regime of high income shares prevailed for 10% and 50% poorest whereas a regime of low share prevailed for Top 10%. During late eighties low income shares regime seemed to have prevailed for poorest quantiles.

4.1.6 Southeast region

Southeast region in Brazil is most developed region of Brazil in many aspects. The income distribution pattern from Southeast contrasts in one aspect from previous regions. There is no evidence of a low share regime during the eighties in both poorest quantiles. From 2000 there is a transition towards a high shares regime in these quantiles. Finally in Top 10% quantile two regime prevailed in most of time. From 2000 up to the end of the sample, a regime of low share prevailed whereas in the rest of sample excepting few year in late seventies and late eighties, a regime of intermediate shares were observed. Finally some peaks in the share were observed in late seventies and eighties.

4.2 Multivariate Structural Time Series Model:

We also estimate a local linear trend state space multivariate time series model with an autoregressive stationary component for Brazilian regional data as described in equations (4) up to (7). The
Figure 5: Regime probabilities obtained from a Markov switching model - Brazil and Regions.
goal of this exercise is to identify a statistically significant local trend and change in level component in data quantile. Model structure allow trend to be time variant i.e. it allows different values for trend in each period of time. This is the reason why this methodology is important to help us identify different patterns over forty years of the sample. Trend and level components evolve smooth in state space framework whereas in Markov switching framework regimes change is abrupt. The methodology also allows us to easily tackle missing value of the sample. All estimations were performed in STAMP package of Oxmetrics 7.0 software.

4.2.1 Brazilian data

Figure 6 shows estimates for all components of the state space model for Top 1%, Top 10%, Bottom 50% and Bottom 10% Brazilian income shares. All components are plotted with proper error bands. If at time $t$ the lower bound of the band is bigger than all previous values of the upper bound of the band up to time $t$ it is possible to state that the level has reached a peak at time $t$. If a time $t$ the upper bound is smaller than all previous values of the lower bound of the band up to time $t$ it is possible to state that the level has reached a trough.

The first set of graphs of Figure 6 show time evolution of level component estimates. It is possible to conclude from them that Bottom 10% and Bottom 50% started to reach a sequence of peak values around 2002. The level component remained statistically above the values that had prevailed up to 2002. This suggests that there is a significant improvement in the shares of these quantities in Brazil income distribution. Although some changes seemed to occur in Top 1% and Top 10% quantiles, there is no evidence of a statistically significant difference among periods. Major changes in income distribution pattern seem to be related to the change in lower quantiles whereas income shares of top quantiles remained stable.

Inspection of autoregressive component estimates ($\psi_t$) suggests that a fall and recovery event took place in 1989 and 1990 at Bottom 50%, Top 1% and Top 10% quantiles. These movements are closely related to the macroeconomic instability of Brazilian economy at the time. The highest level of inflation ever reached in Brazilian History occurred in this year. Fall in income shares quantile is observed in 1989 whereas an opposite movement was observed in top quantiles. Moreover, component level of Bottom 10% quantile reached its lowest level in 1989 and it can be classified as a trough. Recovery was slower than in others quantiles.

Finally local trend ($\beta_t$) component seems to be statistically insignificant for virtually all the sample excepting years about 1994 when Brazilian managed to implement a successful Macroeconomic Stabilization Plan.

Summing up national picture suggest that a statistically significant movement towards a more
equal income distribution patterns at unprecedented levels started about early years 2000 decade and macroeconomic instability at the end of the eighties had a deleterious effect on income distribution.

4.2.2 North Region:

Figure 7 shows estimates for all components of the state space model for Top 1%, Top 10%, Bottom 50% and Bottom 10% Brazilian North region income shares. Similar to Brazilian picture there is no evidence of a statistically significant change in the level component estimates in Top 1% and Top 10% income shares. Looking at Bottom 50% income quantile, there is a statistically significant drop in the level in late eighties and a recovery had started only about 2002 suggesting that the macroeconomic instability during the eighties had a deep impact on income distribution in the region. Bottom 10% income shares also fell substantially during the eighties. Contrary to Bottom 50% income quantile, evidence of a sustainable recovery is not strong. Income share were at the beginning of 2010 decade at the same level of the 1970. Figures for this Bottom quantile has not shown any improvements.

4.2.3 Northeast Region:

Figure 8 shows estimates for all components of the state space model for Top 1%, Top 10%, Bottom 50% and Bottom 10% Brazilian Northeast region income shares. Top 1% income share quantile did not show substantial changes during all the period covered by the sample whereas a steady drop in Top 10% can be detected. Trend component is negative and statistically significant from 2000 onward, showing that a negative trend was operating. Bottom 50% quantile started to exhibit successive peaks after 2005 and at the end sample level component is at highest level in the sample. Putting these two pieces together, it is possible to conclude that there was a redistribution of the share from Top 10% to Low 50% in this region contrasting with Brazilian picture.

Level of the poorest quantile, Bottom 10%, reached a trough in early years of the nineties after a major fall that started in the early days of the eighties. After 2000, the level is statistically significant higher than the trough but also significant lower than the level prevailing in the end of seventies. Contrary Brazilian picture, the dynamics of Bottom 10% contribute to rise income inequality.

Summing up, nothing worth mentioning happened in the Top 1% quantile whereas significant changes were observed in other quantiles. Bottom 50% quantile showed a significant improvement but Top 10% quantile income shares remained below the level of the seventies. The poorest seemed to be negatively affected by macroeconomic instability of the eighties by loosing their shares in total income.
Figure 6: State-Space Model Components for Brazil - Top 1%, Top 10%, Bottom 50% and Bottom 10% Income Shares
Figure 7: State-Space Model Components for North Region - Top 1%, Top 10%, Bottom 50% and Bottom 10% Income Shares
Figure 8: State-Space Model Components for Northeast - Top 1%, Top 10%, Bottom 50% and Bottom 10% Income Shares
4.2.4 Midwest Region:

Figure 9 shows estimates for all components of the state space model for Top 1%, Top 10%, Bottom 50% and Bottom 10% Brazilian Midwest region income shares. In top 1% income quantile, there is no evidence of significant changes in level component. There is some evidence that Bottom 50% quantile shares and Top 10% quantile shares reached a peak and trough respectively at the end of the sample. Furthermore, both Bottom 10% and Bottom 50% reached a trough in the end of eighties, suggesting that macroeconomic has caused a deterioration of income distribution in the region at that period. Bottom 10% quantiles shares level at the end of the sample is not statistically different from the one prevailing at beginning of the sample. Basically no improvement at all in the lowest quantile. Finally some spikes in others components were detected. ($\beta_t$ and $\psi_t$).

4.2.5 Southeast Region:

Figure 10 shows estimates for all components of the state space model for Top 1%, Top 10%, Bottom 50% and Bottom 10% Brazilian Southeast region income shares. There is no significant changes in the level component for both Top 1% and Top 10% income quantiles during the whole period of the sample. Contrasting to others regions and national evidence, it is possible to detect a significant and positive local trend in the second half of the eighties and afterwards in Bottom 50% and Bottom 10% income shares quantile suggesting that movements towards a more equal income distribution pattern may have started before than other regions in the country. But it must be stressed that a significant peak can only be detected during the first decade of 2000. Time evolution of autoregressive estimates of Bottom 50% and Bottom 10% and Top 10% quantiles also suggest a great volatility in income during the eighties and first half of nineties. During second half of the nineties and first decade of 2000, a significant but temporary drop (rise) in income inequality were observed in Bottom 50% and Bottom 10% (Top 10%). Nothing worth mention had happened int Top 1% autoregressive estimates.

4.2.6 South Region:

Figure 11 shows estimates for all components of the state space model for Top 1%, Top 10%, Bottom 50% and Bottom 10% Brazilian Southeast region income shares. Time evolution of level component estimate for Top 1% does not show evidence in favor of a detectable peak or trough whereas evidence for others quantiles is quite different. For Bottom 10% and Bottom 50% a trough can be detect in the end of eighties due to the macroeconomic instability. Successive peaks can be detected at some point in first half of first decade of two in Bottom 50% and Bottom 10%
Figure 9: State-Space Model Components for Midwest - Top 1%, Top 10%, Bottom 50% and Bottom 10% Income Shares
Figure 10: State-Space Model Components for Southeast - Top 1%, Top 10%, Bottom 50% and Bottom 10% Income Shares
quantiles. It is also possible to detect a sequence of trough in level component fro Top 10% in the same period. It is safe to conclude that movements in income inequality index are closely related to what was happening in Top 10%, Bottom 50% and Bottom 10% quantiles.

5 Final Remarks

The discussion on income inequality in Brazil has grown in the last decade, mainly due to changes in economic, political and social environment over the past 40 years of its History. During seventies Brazilian economy faced a period of economic prosperity with many people evolving to middle class standards. The second round of oil prices increases in late seventies had a decisively negative impact on Brazilian growth. During the eighties Brazilian economy faced economic downturn, hyperinflation and bailouts.

This paper analyses the evolution of household income inequality in Brazil using aggregated and regional data from 1977 to 2013. Brazilian National Household Survey data is used and four income shares quantiles are investigated such as Top 1%, Top 10%, poorest 10% and poorest 50%.

Our results can be stated on two dimensions. Allowing for three different regimes, our estimations suggest that for Top 1% and 10% income individuals one can observe a reduction in their shares in Brazil and most regions from the first decade of twentieth century onward. This is more pronounced for Top10%. A opposite movement in terms of increase in share participation is observed for the poorest individuals (bottom 10% and 50%), more pronounced for bottom 50%. However for those on the lowest quantiles we observe an improvement of their shares before 2000 suggesting a previous improvement in the income of those at the bottom before decreasing income participation of those at the very top. That phenomenon seems to take longer in Northeast and North regions, i.e., an increase in the participation shares for the lowest quantiles only after 2000.

The second dimension is related to the results concerning multivariate structural time series model that allows us to decompose for transitory versus permanent movements on the series of income participation for Top 1%, Top 10%, Bottom 10% and Bottom 50% and their statistical significance. For those at the top 1% quantile we cannot reject the null that there is no trend in any period and there is no detectable peak or trough for Brazil and most regions. However, for those at the bottom we observe a successive improvements for Brazil and most regions reaching successive peaks of income shares from beginning 2000’s onward.

The results also suggest not only that high inflation has produced a large income inequality in Brazil, but that there has been occurred a large improvement after inflation has been controlled in Brazil and all regions. That was more pronounced after 2000. Minimum wage policy and social
Figure 11: State-Space Model Components for South - Top 1%, Top 10%, Bottom 50% and Bottom 10% Income Shares
programs seem to have improved income distribution after 2002. Kuznets and Jenks [1953] argued that income inequality first rises with economic development where concentrated sectors push for development but then decreases as workers join the high-paying sectors of the economy. Our data show that this may not be the reason that income inequality increased in the 80’s, a recession period. Furthermore we observe a decrease in income concentration during the end of 90’s, a growth-recovery period with much lower inflation.

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