Social Security Effects on Income Distribution: A Counterfactual Analysis for Brazil*

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Abstract

According to Diamond (1977), one of the reasons for the existence of social security systems is that they function as an income redistribution mechanism. There is an extensive literature that tests whether social security systems produce the desired results in developed countries (mainly for the U.S.A.). Nevertheless, there is not an "obvious" consensus about this social security property and there is little evidence for developing countries. In this article, we test this property for the Brazilian Social Security System. In addition, we also look at another question which has not been answered yet in the previous literature. Is the trend of social security systems increasingly progressive or regressive? We conclude that the changes in Brazilian Social Security legislation reduced inequality between 1987 and 1996, but only for the elderly. For the other age groups, there is a stable trend. Results for the period between 1996 and 2006 reveal that the Brazilian system is neutral for all cohorts. Therefore, we found out that social security systems are not an effective mechanism for income redistribution, as predicted by previous studies.

Keywords: Social Security, income distribution, counterfactual distribution.

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1 Introduction

The Brazilian Social Security System follows a pay-as-you-go (PAYG or unfunded) retirement system, like the German, French, Japanese and American systems, in which each generation of workers (current taxpayers) provides financial support for the preceding generation's retirees and pensioners. Due to a peculiar financial design, PAYG is vulnerable to some social changes such as demographic and labor market developments. Indeed, there is a consensus that PAYG systems produce an increasing burden on every nation's budget. Many modern societies have witnessed a worsening situation in their social security systems.

In Brazil, for example, social security deficit has reached 5% of GDP, one of the highest in the world (Tafner and Giambiagi, 2007). This highlights the fact that the Brazilian system seems to be heading towards insolvency in the future. This has, in fact, been the subject of much public discussion. Proposals for reform of the social security system in Brazil range from a simple invalidation of male/female age differential as a rule for benefit payments to a complete institutional change in the direction of a funded system, as occurred in the 1980s in Chile.

In this paper, instead of addressing the discussion on what kinds of changes must be made for a better Brazilian system, we think it is important to provide a short discussion of the reasons that justify the existence of public pension systems. Diamond (1977) points out three main justifications for a social security: redistribution of income, market failures and paternalism.

Redistribution of Income First, public pensions redistribute income. Ideally, redistribution should be implemented by income taxation on a lifetime basis. Unfortunately, such redistribution is rather limited in practice. Annual income taxation is imperfect in terms of income redistribution since the measurement of an individual's income is restricted to a point in time, without defining the needs or capacities of payment, which change throughout the work cycle. Social security, in some countries like Brazil, sets up the benefit formula based on an average of the highest pre-retirement earnings and not as a function of the wage profile throughout the working period. In intragenerational terms, social security works as a complementary mechanism of redistribution to the income taxation. In intergenerational terms, the increase in the benefits in a small fund (as in PAYG) produces a redistribution from the very young to the very old since social security taxes paid by today's workers and their employers are used to pay the benefits for today's retirees and other beneficiaries. This kind of redistribution would be appropriate if the oldest generation were poorer on average or if one or more generations experienced long periods of economic recession.

Market Failures Second, public pensions provide social insurance in a number of ways related to health, longevity and financial risks in the presence of market failures. We point out the inability of the private market to provide insurance against the risk associated with someone's working period in the case of moral hazard and adverse selection. Those risks would be: (i) a reduction in earning capacity due to illness, disability or death; and (ii) an increase in the disutility of labor because of failing health or declining motivation to work. Thus, social security would act as a mandatory social insurance against a decline in earning power over the individual's life cycle. In the case of such risks, social security benefits would provide early retirement pensions and disability benefits for those who are incapable of working because of illness or disability.

With regard to market failures, we point out two main reasons for a retirement age. First, it is the presence of asymmetric information in the market of an annuity[1]. Agents with a higher life expectancy would look for this market. So, the price of perpetuity would increase until there is a collapse in the system, driving the market to its own extinction (Rothschild & Stiglitz, 1976; apud, Ferreira, 2007). Government intervenes by defining the age at which an eligible retiree receives social security benefits after having contributed for some period of time. Secondly, competitive equilibrium in an overlapping generation model might not be Pareto-efficient. In the absence of a social security program, people overaccumulate capital over their life cycle, and when they make decisions about savings they do not worry about future generations. So, there is room for government intervention. The dynamic inefficiency in the economy would be reduced by the implementation of a mandatory PAYG social security system that would cause a fall in capital stock and an increase in the level of consumption[2] .

Paternalism Finally, social security systems force savings. They identify a paternalistic social objective since the utilitarian welfare function depends on ex post utilities. Indeed, government intervention is needed if some individuals are inclined to save less than the amount set aside through payroll taxes. This might occur due to: (i) an incorrect evaluation of current savings according to future needs; (ii) the difficulty of making savings decisions under uncertainty; (iii) agents' irrationality as they are future-myopic (strong preference for the present); (iv) the Good Samaritan's dilemma, when agents save very little because they know society will provide resources at the end of their working years[3]. Therefore, a pension scheme with forced savings would play an important role in the social security system.

According to the first public pension function, public pensions work as a mechanism of income distribution by carrying out public policies in a distributive way. However, at a lower level, as pointed by Tafner (2007), public pensions, just as social insurance, also generate income redistribution in two circumstances: (i) in case of an event (illness, disability or death), a single individual (or his family) receives retirement benefits for the rest of his life regardless of how many years he collected social security tax; and (ii) if his life expectancy is sufficiently high after retirement, he is guaranteed payments that are more than what he paid into the system.

If social security is an advantageous contract for a certain group of people, in particular the poorest ones, then there is a progressive income distribution[4]. Otherwise, there is a regressive

[1]In finance, an annuity is a bond in which periodic payments begin on a fixed date and continue indefinitely. Also, annuity can be the right to receive amounts of money regularly over a certain fixed period, in perpetuity, or, especially, over the remaining life or lives of one or more beneficiaries.

[2]According to Blanchard & Fischer (1989), any Pareto improvement occurs when the rate of return paid by the government (which equals the population growth rate) is higher than the interest rate.

[3]Following Becker & Murphy (1988).

[4]Progressive means when social security achieves a better income distribution. A social security system is progressive when lower-income individuals pay (receive) proportionally less (more) taxes (benefits) than those

income distribution[5].

There is a wide range of literature that regards social security systems as good policy instruments for income distribution in industrial countries, especially in the U.S., but there is no clear consensus about that[6]. In this paper, we evaluate the distributive property of public pensions and try to answer an additional question which has not yet been answered by the literature: "Is the trend of social security systems increasingly progressive or regressive?" Both aspects will be considered for Brazil because: (i) there is little evidence for developing countries which are characterized by high social security expenditure. As already mentioned, in Brazil, the social security deficit is one of the highest in the world; (ii) Brazil shows a high degree of income inequality[7], ranking as the tenth most unequal country in a sample of 126 countries in 2006 (UNDP, 2006).

In order to perform the test, we will deal with taxes and benefit payments. In a distributive analysis, it is important to consider worker's social security contribution and benefit flows

Given the changes in the demographic structure in Brazil, there has been a significant increase in the share of beneficiaries of the social security system. By controlling some factors, if public pensions have a progressive distributive pattern, we would understand that income inequality might be diminishing. This does not occur in Brazil. For almost two decades, the Gini coefficient has been close to 0.60 and has not decayed significantly[8].

In order to test the distributive pattern of the system, we shall define the most adequate income measurement. We observe an increase in the social security tax rate (worker and employer) and in the number of beneficiaries. If we consider that elasticity of tax income is zero, i.e., any increase in the tax rate is not passed on by the firm as a wage reduction, we believe workers' gross earnings serve as a measure for social security progressivity. By dealing with infinite elasticity of tax income, i.e., any increase in the tax rate is fully charged by the firm as a wage reduction, we consider workers' net earnings (gross earnings minus contributions). In this case, we choose the latter because it is possible to verify the impact of taxes and benefit payments, and also because net current income is the most adequate measure in an income inequality analysis.

Furthermore, we observe that lifetime earnings are more appropriate when dealing with the assumption of perfect credit markets, when agents do not have any constraint on borrowing and reallocating wealth from future to present. However, since we consider market failures and, hence, imperfect credit markets, individuals cannot borrow. In general, developing countries tend to face more credit constraints than industrial ones. That is why we use current income[9].

In Brazil, if a covered worker dies, his or her spouse and children may receive survivors' benefits in a direct (pension) or indirect way (retirement). A broader and more precise analysis

with a higher income.

[5] Barros & Carvalho (2005) and Tafner (2007) state that the Brazilian social security system is a regressive one.

[6] Some of these studies will be commented in the current text.

[7] Only in recent years has inequality declined. However, not due to the Social Security System, according to Barros et al. (2007).

[8] See the preceding footnote.

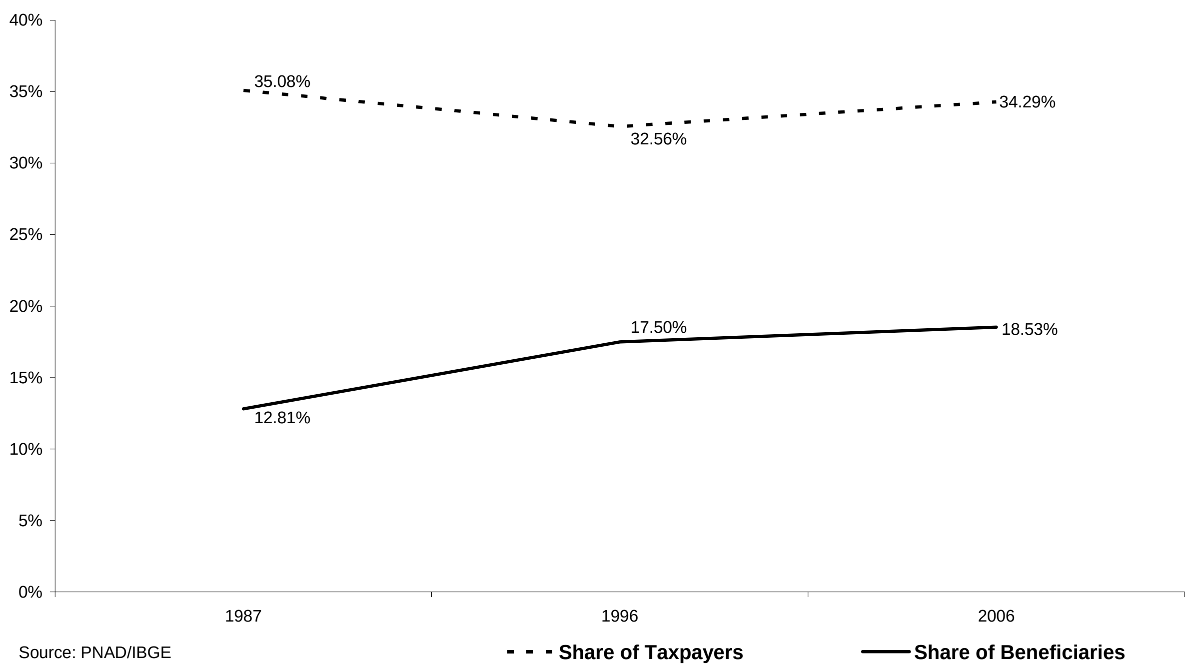
[9] The same assumption is assigned for rural workers by De Carvalho Filho (2008).

of the distributive effect of the social security system does not consider individual income but rather family income. If we take the sum of workers' net earnings of all family members, in per capita terms, we treat the beneficiary's family as a beneficiary and assign that larger families are more dependent upon the social security system.

Still with regard to testing the distributive pattern of the system, in terms of methodology, we look closely at what would happen to per capita family income distribution in Brazil if there were the same share of beneficiaries and taxpayers as 10 years ago. We had two alternative approaches: (i) a simple regression of wages or (ii) an estimation of densities. The advantage of the latter is the accountability of income distribution. Also, it is possible to calculate various metrics of income inequality and compare them with the real ones. If the social security system has really turned into a more progressive one, we expect to find an improvement in income distribution.

Summing up the strategy to test the distributive pattern of the social security system, we first describe the sample. After that, we calculate the Gini coefficient and the Theil index for wages subtracted by benefits. Then, we obtain these same inequality indices for wages added by contributions. By comparing real Gini coefficients, we have the joint effect of taxes and benefit payments on income distribution. Later, we change the distribution of beneficiaries and taxpayers, controlling for their individual attributes and for geographic characteristics. Also, we estimate a new distribution of per capita family income. At this point, we follow Dinardo, Fortin and Lemieux (1996) to disaggregate counterfactual densities. In addition, we extend the methodology by incorporating contribution flows. Using this general procedure, we achieve a more precise analysis of changes of the progressivity (regressivity) in the social security system.

Graph 1. Beneficiaries/Taxpayers over 18 years old in the Brazilian Population (%)



Source: PNAD/IBGE

In this analysis, an important assumption is that the changes in social security rules are signaled by the share of beneficiaries and taxpayers. Graph 1 shows that the share of beneficiaries has increased by more than 35% in Brazil: from 12.81% in 1987 to 17.50% in 1996, including an increase of more than 6 basis points in the 10-year period until 2006. At first, the share of taxpayers decreased from 35.08% in 1987 to 32.56% in 1996 and increased to 34.29% in 2006. Results for the Gini coefficient and the Theil index show that income distribution tended to improve when social security rules were fixed in 1987. This means that the social security system has become more regressive. However, when considering factors such as education, living and residence standards in 1987, the impact of benefits is almost null; that is, those factors explain mainly inequality evolution, reducing the potential effect from social security.

The paper begins in Section 1 by presenting the main functions of the public pension system and then reviews, in Section 2, the literature according to international and Brazilian evidence. Section 3 provides the descriptive statistics and Section 4 explains the methodology used for measuring the distributive pattern of the social security system. Section 5 discusses the results. Section 6 concludes.

2 Literature Review

In what follows, we present a selective review of the American and Brazilian literature related to the distributive aspects of social security.

International Evidence Feldstein (1976) considered benefits as part of total family wealth in the U.S. The author suggests that social security systems provide resources within each generation by attempting to give higher returns to lower-wage workers, which reduces their need for fungible wealth accumulation[10]. For 1962 data, he shows that this kind of wealth inequality is higher than total wealth, which is the progressive distributive pattern of the American system.

Evidence is not conclusive, though. Recent studies using an OLG model calibrated to study the transmission of wealth inequality via bequests by Gokhale & Kotlikoff (2002a, 2002b) and Gokhale et al. (2001) show that social security may greatly increase the inequality in wealth distribution and Gini coefficients by 11% (Gokhale & Kotlikoff, 2002a) and 21% (Gokhale & Kotlikoff, 2002b). One of the reasons is that social security transforms bequests into a non-egalitarian force because low-income households rely almost entirely on social security to finance their retirement consumption, decreasing bequeathable wealth by more than 50%. In contrast, higher-income households have substantial wealth to be passed along to their heirs. The main reason is the American ceiling for social security taxation. As a result, wealthier individuals generally receive larger benefits than poorer taxpayers. Liebman (2002) employs a social security microsimulation model. The model simulates the distribution of internal rates of returns, net transfers and lifetime net tax rates from social security that would have been received by individuals born between 1925 and 1929 (age of 73 and 77 in 2002) if they had lived under current social security rules for their entire lives. The author finds that social security

[10] Feldstein (1976) defines fungible wealth as total wealth minus social security wealth.

redistribution is not related to income. Even though social security is thought to be progressive because it redistributes income from the wealthy to the poor, it also transfers income from people with low life expectancies to people with high life expectancies, from men to women, from single workers and from married couples with substantial earnings by the secondary earner[11] to one-earner married couples, and from people who work more than 35 years to those who concentrate their earnings in 35 or fewer years. One of the reasons why progressivity of income redistribution in social security system is highly modest is that wealthier individuals generally have higher life expectancies and receive higher benefits from their partners. Results point out that 19% of individuals in the largest quintile of lifetime income receive net transfers higher than the average transfers to people in the shortest quintile. Coronado et al. (2000) classify individuals by annual income and the Gini coefficients show that the system is highly progressive. Gradually, they control for many factors and recalculate the Gini coefficients for every step. According to the potential lifetime income criterion [12,13], they take into consideration that wages above the ceiling are taxed up to the ceiling wage[14], adding together the incomes of spouses such that each individual is classified based on the lifetime per capita family income[15], incorporate mortality probability[16] and increase discount rate from 2 to 4%[17]. As a result, the progressivity of the system reduces until it becomes regressive.

Brazilian Evidence Afonso & Fernandes (2005) estimate intragenerational and intergenerational distributive aspects of the Brazilian social security system by calculating the internal rate of return, which comes from the comparison between benefit and contribution flows of individuals in their lifetime. The authors extract benefits and infer contributions from the Brazilian National Household Survey, known as PNAD. Contributions also require the distribution of tax payments for different occupational groups according to the restrictive assumptions about civil servants, own-account and autonomous workers. As a result, the authors imply that the Brazilian social security system is progressive in intragenerational terms (internal rates of return are higher for lower education workers and for those from the Northeast of Brazil, who are also those with lower income per capita) and in intergenerational aspects (internal rates of return decreased from 1980 to 1989 and have been constant since then).

[11] In the U.S., 50% of a living retiree's benefit goes to his (her) partner. After his (her) death, the secondary earner receives the total amount as when he (she) was alive.

[12] The progressivity of social security is reduced because lifetime income classifies retirees with zero earnings according to their lifetime revenues. Therefore, agents who work part-time or spend many years of their time out of the labor force are no longer classified as low-income.

[13] The potential lifetime income is the projection of a wage rate for each individual in each period, multiplied by the total number of hours, resulting in a welfare measure that includes leisure and domestic output instead of job opportunities only.

[14] This taxable maximum was already discussed in the previous paragraph and reduces the progressivity of the system.

[15] The low-wage spouse is not that poor anymore. This further reduces the progressivity of the system.

[16] As individuals with a higher income live longer, they receive benefits for a longer time and, in terms of measure of current earnings, they tend to receive larger benefits. Thus, after these adjustments, the system is too little progressive.

[17] This places more weight on regressive payroll taxes in older years and less weight on progressive benefit patterns in more recent years.

However, according to the Gini coefficient decomposition method, Ferreira (2006) shows that retirements and pensions increase the level of per capita household income inequality in Brazil. Besides, social security gains are the second highest element in the calculation of the Gini coefficient, followed immediately by wage earnings. These gains increased from 9.3% in 1981 to 18.8% in 2001 and remained constant. Hoffmann (2003, 2005) corroborates the findings of Ferreira (2006) by using the same Gini coefficient decomposition approach. In addition, Hoffman (2005) applies two other decompositions: Mehran coefficient decomposition (more sensitive to changes in the left tail of the distribution) and Piesch coefficient decomposition (more sensitive to changes in the right tail of the distribution). Both studies indicate that retirements and pensions contributed to a higher inequality in 1999 (Hoffmann, 2003) and in the years 2002 to 2004 (Hoffmann, 2005). Tafner (2007) examines the effect on family poverty using a three-scenario analysis: (i) before benefit payment; (ii) after benefit payment; (iii) simulation on the poorest. All scenarios consider the amount of transfers constant. The author concludes that the social security system prevents poverty. Nonetheless, if the social security program had focused on the poorest, there would have been more significant poverty prevention. So, the social security system does not result in a significant inequality reduction and it has not been efficient in terms of income distribution. Hence, it shows malfunctions in the income transfer program.

According to Ferreira (2006), the causes for regressivity in the Brazilian social security system are early age retirement; increase in life expectancy, meaning retirees collect benefits longer; higher wages for high-income beneficiaries. All of these factors turn into a worse income distribution. Besides, the causes for a worse deficit in the Brazilian system are related to the composition and informality of the labor market; flexibility in labor contracts (reduction of fixed salary and increase in profit sharing agreements, which exclude social security taxation); demographic trends (the number of workers paying into the program continues to decline relative to those receiving benefits); legislation (extended benefits provided for by the 1988 Constitution). Tafner (2007) also points out that social security net transfers are not only related to income, but also to the occurrence of events. As an example, if wealthier individuals become invalid, they will receive benefits for their whole life and will be financed by poor people, which illustrates redistribution of wealth from the poor to the wealthy.

Thus, Brazilian evidence is still inconclusive. In this paper, we consider an alternative method to verify the redistributive pattern of the Brazilian social security system.

3 Data and Descriptive Statistics

This paper uses data from the PNAD (Brazilian National Household Survey) to analyze two sets of pairwise years: 1987/1996 and 1996/2006. The ultimate goal is to obtain a more robust and precise evaluation of the distributive characteristics of the social security system[18]. In fact,

[18] It is important to mention some limitations of the study due to the PNAD data: (i) it is not possible to separate rural beneficiaries from urban ones. According to different rules, it would mean a great improvement to the work; (ii) it is not possible to determine if a retired individual is a civil servant or an ordinary worker in the private sector; (iii) it is not possible to know when a retirement occurred; and (iv) it is not possible to control for

there were two important structural breaks in each set: (i) 1987/1996: The Constitution of 1988 altered social security rules; and (ii) 1996/2006: The Social Security Reform in 2003 altered the rules for civil servants.

The analysis requires the application of filters. First, all observations with individuals under the age of 18 years were excluded from the samples. Anyway, this represents a small percentage of beneficiaries[19], only 2% of the total. Second, we exclude all households in which all members declared receiving no income[20]. So, only individuals aged over 18 years and reporting some income were kept in the sample. The descriptive statistics of the sample is shown below.

We notice that the share of beneficiaries has increased enormously up to 35% (Graph 1 in the Introduction). Table 1 in Appendix A indicates that the number of beneficiaries also increased: from 10.10 millions in 1987 to 16.13 millions in 1996 and 22.95 millions in 2006. Pensions showed a huge increment in terms of relative participation: from 24.48% in 1986 to 36.10% in 2006. Elderly people (over 58 years old) constitute a high share of beneficiaries that has been increasing over the years.

In terms of share of taxpayers, there has been a recovery in the last decade after an initial slowdown. The number of taxpayers has almost doubled: from 27.5 million in 1987 to 41.78 million in 2006. Ordinary workers are the ones who pay more. In general, since 1996, the share of contributions has raised to a high degree especially as a result of the Social Security Reform in 2003, which has enlarged the number of contributions by incorporating retired civil servants.

We have calculated the Gini coefficient and Theil index for the whole filtered sample and for age groups. We subtracted benefits and added tax payments, separately and jointly. Table 2 shows the estimations for these coefficients as gross samples with no controls. By comparing (1), benefits induce a reduction in net family income per capita inequality for individuals aged over 18 years. That is, the social security system is a progressive system, in terms of benefits. Moreover, the system has become more and more progressive as column "(1)/Factual" shows absolute gains over the years. Also, by comparing (2), contributions have no distributive effect. Jointly, taxes and benefit payments have a progressive effect on inequality, in level and monotonic terms. Note that the reduction in the inequality level is up to 9.5% for the Gini coefficient and 19.5% for the Theil index. Even according to age groups, the benefit effect is progressive and increases with age. For early ages, there is a relatively small gain. Also, the tax payment effect is negligible.

informality once information about the labor market is not available. Afonso & Fernandes (2005) had the same limitation. Another element is the inexistence of questions about tax values. Following Afonso & Fernandes (2005)'s strategy, we obtained the following from PNAD data: values for earnings, an indicator function for taxpayer (or not) in every occupation, type of occupation in productive activity (ordinary worker, civil servant, houseworker or autonomous worker). Then, social security taxes and rates were obtained for every working group from each occupation's earnings. In Appendix B, in Table 9, we show a brief description of legislation history and rates applied.

[19] We consider beneficiaries those who receive a positive income from retirement, pension or nonretirement allowance. In earlier PNAD data, there is no question about whether the individual is a retiree/pensioner or if he (she) receives any kind of nonretirement allowance. The only question was about what the individual had done during the week. A busy retiree would have answered that he (she) worked as usual. This means a biased share of beneficiaries in earlier pools.

[20] Densities are estimated for the logarithm of income.

For individuals under 47 years old, the joint effect (contribution and benefit) of progressivity increase is smaller (see column "Factual/(3)"). Nonetheless, for individuals aged over 48 years, taxes and benefit payments imply progressivity in income distribution, and changes in social security rules have turned the system into a more progressive one. In the U.S., Feldstein (1976) and Coronado et al (2000) reached similar evidence when they also did not control for several factors.

As mentioned before, the use of controls is highly required to separate the real effect of an improvement of the social security system. To achieve that, we consider kernel density estimation.

4 Methodology

Following Dinardo, Fortin and Lemieux (1996, hereinafter DFL), we use weighted kernel density estimators[21]. The kernel density estimate $\widehat{f_h}$ of a univariate density f based on a random sample of wages [22] $\{W_i\}_{i=1}^{n}$of size n, with weights$\{\theta_i\}_{i=1}^{n}$, $\sum_i \theta_i = 1$ is:

$$\widehat{f_h} = \sum_{i=1}^{n} \frac{\theta_i}{h} K\left(\frac{w - W_i}{h}\right),$$

where h is the smoothing parameter (or bandwidth) and $K(.)$ is the kernel function. According to Silverman (1986), there are few efficiency differences (in terms of the norm of integrated mean square error) among different kernels. So, the kernel function used is Gaussian kernel as in DFL. As bandwidth selector, we use Silverman's rule of thumb (1986), based on the standard deviation and interquantile range:

$$h = \frac{0.9 \min\{\sigma_w, R_w/1.34\}}{n^{1/5}}$$

where σ_w is the standard deviation of the sample and R_w is its interquantile range. In all nonparametric estimates, the domain of estimated densities is the logarithm of income, whose support is defined on the interval [0.01,14], with steps of 0.01, including the whole income mass.

4.1 Estimation of Counterfactual Densities

The procedure in DFL allows for the analysis of the whole distribution. Our estimation of counterfactual densities intends to answer the following question: "what would the density of wages have been in 1996 if the share of beneficiaries-taxpayers had remained at its 1987 level"[23].

[21] DFL adapted these estimators, which were originally introduced by Rosenblatt (1956) and Parzen (1962).

[22] Wages refer to logarithm of *per capita* net family income.

[23] This counterfactual approach is subject to Lucas critique. That is, individuals could change their behavior if a change in government policy is expected, such as an increase in benefits. The technique does not incorporate adjustments and expectations from individuals. For instance, we could mention a change in the decision of a woman who receives a pension and could separate from her husband because she used to be battered.

Nonetheless, it is important to mention that the technique is a good approximation to analyze the economy under a sudden change in social security legislation, but it does not allow for people's behavioral changes. Therefore, before the counterfactual exercise, the economy is in a steady state equilibrium, but after the change in rules, this method no longer considers the agents' expectations and adjustments.

Consider each observation as a vector (w, z, t), where w is the logarithm of the sum of net earnings of all family members in per capita terms (continuous variable), z are the individual attributes (dummy for beneficiaries and taxpayers, dummies for schooling years, age, race and marital status, dummy for whether the individual is head of family, interaction dummy for head of family and sex, total hours of work, place of residence [urban or rural] and dummies for the states where the individual lives) and a date t, which takes only two values in the comparisons and includes years 1987, 1996 and 2006. The subvector z is divided into three parts: $z = (b, c, x)$, where b is a dummy variable for beneficiaries, c is a dummy variable for taxpayers and x are all other factors. This division (into b,c and x) is due to the focus of our paper on the social security structure, denoted by variables b and c, which have been altered over the last years. Consider the joint distribution of wages, individual attributes and dates, $F(w, b, c, x, t)$. This distribution of wages and attributes at one point in time is the conditional distribution $F(w, b, c, x|t)$. The density of wages at one point in time, $f_t(w)$, can be written as the integral of the density of wages conditional on a set of individual attributes and on a date $t_{w|b,c,x}$, $f\left(w|b, c, x, t_{w|b,c,x}\right)$, over the distribution of individual attributes $F(z|t_z)$ at date t_z:

$$
\begin{aligned}
f_t(w) &= \int_{x\in\Omega_x}\int_{b\in\Omega_b}\int_{c\in\Omega_c} dF(w, b, c, x|t_{w,b,c,.x} = t) \\
&= \int_{x\in\Omega_x}\int_{b\in\Omega_b}\int_{c\in\Omega_c} f\left(w|b, c, x, t_{w|b,c,x} = t\right) dF(b|c, x, t_{b|c,x} = t)dF(c|x, t_{c|x} = t)dF(x|t_x = t) \\
&= f\left(w; t_{w|b,c,x} = t, t_{b|c,x} = t, t_{c|x} = t, t_x = t\right),
\end{aligned}
$$

where $\Omega_x, \Omega_b, \Omega_c$ is the domain of definition of the individual attributes. The notation $t_{w,b,c,x} = t$ represents the values of wages, share of beneficiaries, share of taxpayers and all other individual attributes at date t. For example, $f\left(w; t_{w|b,c,x} = 96, t_{b|c,x} = 96, t_{c|x} = 96, t_x = 96\right)$ represents the actual density of wages in 1996. In the case of $f\left(w; t_{w|b,c,x} = 96, t_{b|c,x} = 87, t_{c|x} = 96, t_x = 96\right)$, it represents the counterfactual density of wages in 1996 if **only** the benefits (variable b) had remained at their 1987 level, while all other attributes had been according to the wage schedule observed in 1996. Under the assumption that the 1996 structure of wages[24], $f\left(w|b, c, x, t_{w|b,c,x} = 96\right)$, does not depend on the 1987 distribution of attributes, $dF(b|c, x, t_{b|c,x} = 87)$, we may write the counterfactual density $f\left(w; t_{w|b,c,x} = 96, t_{b|c,x} = 87, t_{c|x} = 96, t_x = 96\right)$, in which **only** the share of beneficiaries is constant at the 1987 level, but the other attributes are at the 1996 level, is[25]:

$$
f\left(w; t_{w|b,c,x} = 96, t_{b|c,x} = 87, t_{c|x} = 96, t_x = 96\right) = \left[\begin{array}{c} \int\int\int f\left(w|b, c, x, t_{w|b,c,x} = 96\right) dF(b|c, x, t_{b|c,x} = 87) \\ dF(c|x, t_{c|x} = 96)dF(x|t_x = 96) \end{array}\right]
$$

$$
= \left[\int\int\int f\left(w|b, c, x, t_{w|b,c,x} = 96\right) \Psi_{b|c,x}(b, c, x)\, dF(b|c, x, t_{b|c,x} = 96)dF(c|x, t_{c|x} = 96)dF(x|t_x = 96)\right], \quad (1)
$$

[24] In the explanation of the methodology, we always used year 1996, with the attributes set at the level of 1987, for simplicity. But, we made inferences by also comparing a diferent pair of years (1996/2006).

[25] We omitted domains for simplicity.

where, $\Psi_{b|c,x}(b,c,x)$ is the reweighting function defined as:

$$\begin{aligned}\Psi_{b|c,x}(b,c,x) &\equiv dF(b|c,x,t_{b|c,x}=87)/dF(b|c,x,t_{b|c,x}=96) \\ &= b\frac{\Pr\left(b=1|c,x,t_{b|c,x}=87\right)}{\Pr(b=1|c,x,t_{b|c,x}=96)}+(1-b)\frac{\Pr\left(b=0|c,x,t_{b|c,x}=87\right)}{\Pr(b=0|c,x,t_{b|c,x}=96)},\end{aligned} \quad (2)$$

where the last part in equation (2) is obtained when b is a dummy such as $dF(b|c,x,t_{b|c,x}) = b\Pr\left(b=1|c,x,t_{b|c,x}\right) + (1-b)\Pr\left(b=0|c,x,t_{b|c,x}\right)$. Note that this counterfactual density is identical to the factual density (1996) except for the function $\Psi_{b|c,x}(b,c,x)$[26]. So, the estimation of counterfactual densities is simply the estimation of the reweighting function. Thus, the counterfactual density kernel estimator is:

$$\widehat{f}\left(w;t_{w|b,c,x}=96,t_{b|c,x}=87,t_{c|x}=96,t_x=96\right)=\sum_{i\in S_{96}}\frac{\theta_i}{h}\widehat{\Psi}_{b|c,x}(b,c,x)\,K\left(\frac{w-W_i}{h}\right). \quad (3)$$

The difference between the actual 1996 density and this hypothetical density represents the effect of changes on the distribution of beneficiaries, *ceteris paribus* all other factors. A way to estimate the reweighting function of equation (2) is by estimating a probit model for each year separately[27], that is, to estimate:

$$\Pr(b=1|c,x,t_{b|c,x}=t)=1-\Phi(-\alpha_t'G(c,x)), \quad (4)$$

where $\Phi(.)$ is a normal distribution function and $G(.)$ is a function of other attributes.

The counterfactual distribution in case b and c would have remained at the 1987 level (if social security system had remained unchanged by the Constitution of 1988), as shown:

$$f\left(w;t_{w|b,c,x}=96,t_{b|c,x}=87,t_{c|x}=87,t_x=96\right)=\left[\begin{array}{c}\int\int\int f\left(w|b,c,x,t_{w|b,c,x}=96\right)dF(b|c,x,t_{b|c,x}=87)\\ dF(c|x,t_{c|x}=87)dF(x|t_x=96)\end{array}\right]$$

$$=\left[\begin{array}{c}\int\int\int f\left(w|b,c,x,t_{w|b,c,x}=96\right)\Psi_{b|c,x}(b,c,x)\,dF(b|c,x,t_{b|c,x}=96)\\ \Psi_{c|x}(c,x)\,dF(c|x,t_{c|x}=96)dF(x|t_x=96)\end{array}\right],$$

where $\Psi_{c|x}(c,x)=dF(c|x,t_{c|x}=87)/dF(c|x,t_{c|x}=96)$. The same way as in (4), it is possible to estimate $\Psi_{c|x}(c,x)$ through a probit model with a dummy variable c and the same set of regressors:

$$\Pr(c=1|c,x,t_{c|x}=t)=1-\Phi(-\beta_t'H(x)), \quad (5)$$

[26] Note that the 1996 factual density could have been written as:

$$\begin{aligned}f_t(w) &= f\left(w,t_{w|b,c,x}=96,t_{c|x}=96,t_x=96\right)\\ &= \int\int\int f\left(w|b,c,x,t_{w|b,c,x}=96\right)dF\left(b|c,x,t_{b|c,x}=96\right)dF\left(b|c,x,t_{c|x}=96\right)dF\left(x|t_x=96\right)\end{aligned}$$

The only difference in relation to equation (1) is the insertion of reweighting function $\Psi_{b|c,x}(b,c,x)$.

[27] More specifically, we estimate this probit model for 1987 and 1996 separately. After that, we insert the adjusted probability $\widehat{\Pr}(b=1|x,t_{b|x}=t)$, and we expand it for the whole sample. Then, when we use the 1996 data, we will have $\widehat{\Pr}(b=1|x_{96},t_{b|x}=96)$ and $\widehat{\Pr}(b=1|x_{96},t_{b|x}=87)$, i.e., the probability of being a beneficiary conditional on the 1996 attributes and 1996 benefits and conditional on the 1996 attributes and 1987 benefits, respectively.

Finally, by altering b, c and x, the counterfactual density is:

$$f\left(w; t_{w|b,c,x} = 96, t_{b|c,x} = 87, t_{c|x} = 87, t_x = 87\right) = \left[\begin{array}{c} \int\int\int f\left(w|b,c,x,t_{w|b,c,x} = 96\right) dF(b|c,x,t_{b|c,x} = 87) \\ dF(c|x,t_{c|x} = 87) dF(x|t_x = 87) \end{array} \right]$$

$$= \left[\begin{array}{c} \int\int\int f\left(w|b,c,x,t_{w|b,c,x} = 96\right) \Psi_{b|c,x}\left(b,c,x\right) dF(b|c,x,t_{b|c,x} = 96) \\ \Psi_{c|x}\left(c,x\right) dF(c|x,t_{c|x} = 96) \Psi_x\left(x\right) dF(x|t_x = 96) \end{array} \right],$$

where $\Psi_x(x) = dF(x|t_x = 87)/dF(x|t_x = 96)$. Applying the Bayes'rule, this ratio can be written as:

$$\Psi_x\left(x\right) = \frac{\Pr(t_b = 87|x)}{\Pr(t_b = 96|x)} \frac{\Pr(t_b = 96)}{\Pr(t_b = 87)}.$$

So, to infer the first ratio, we simply estimate a probit of the year against variable x and for the second ratio we calculate the proportion of observations in each year. We can now estimate the counterfactual densities by operating:

$$\widehat{f}\left(w; t_{w|b,c,x} = 96, t_{b|c,x} = 87, t_{c|x} = 96, t_x = 96\right) = \sum_{i \in S_{96}} \frac{\theta_i}{h} \widehat{\Psi}_{b|c,x}\left(b,c,x\right) K\left(\frac{w - W_i}{h}\right),$$

$$\widehat{f}\left(w; t_{w|b,c,x} = 96, t_{b|c,x} = 87, t_{c|x} = 87, t_x = 96\right) = \sum_{i \in S_{96}} \frac{\theta_i}{h} \widehat{\Psi}_{b|c,x}\left(b,c,x\right) \widehat{\Psi}_{c|x}\left(c,x\right) K\left(\frac{w - W_i}{h}\right),$$

$$\widehat{f}\left(w; t_{w|b,c,x} = 96, t_{b|c,x} = 87, t_{c|x} = 87, t_x = 87\right) = \sum_{i \in S_{96}} \frac{\theta_i}{h} \widehat{\Psi}_{b|c,x}\left(b,c,x\right) \widehat{\Psi}_{c|x}\left(c,x\right) \widehat{\Psi}_x\left(x\right) K\left(\frac{w - W_i}{h}\right),$$

that is, we multiply the new weights by the weight extracted from PNAD, according to each density. Thus, the change in variables for the 1987 level will be in the following order: benefits, contributions and other factors. This decomposition is called **normal decomposition**[28], whose results will be shown in the following section.

Before that, it is important to highlight that the estimation of densities was made for the logarithm of income. To do so, we need to obtain the distributions of income level. It is a simple procedure. Consider the wage variable as $v = exp(w)$, such that the distribution function is $F_v(\bar{v})$. We have the following transformation:

$$F_v\left(\bar{v}\right) = \Pr\left(v \leq \bar{v}\right) = \Pr\left(\exp\left(w\right) \leq \bar{v}\right) = \Pr\left(w \leq \ln\left(\bar{v}\right)\right) = F_w\left(\ln\left(\bar{v}\right)\right).$$

By differentiating it, we have the density function:

$$f_v\left(\bar{v}\right) = \frac{f_w\left(\ln\left(\bar{v}\right)\right)}{\bar{v}} = \frac{f_w\left(\bar{w}\right)}{\exp\left(\bar{w}\right)}.$$

that is, simply take the estimated density for the logarithm of income and divide it by the exponential of the domain. From this density, it is possible to infer many inequality metrics.

5 Results

First, probit models (4) and (5) were well adjusted as shown in Tables 4 and 5. The estimated probits for variables b and c, as dependent variables, had a high percentage of correct classification (around 90 and 80%, respectively), as well as high Pearson's statistics and predictive power measure for the estimated models in a general sample (individuals aged over 18 years).

[28] In the next section, we consider reversing the order of change in the variables.

From the estimation of densities for counterfactual considerations, Table 5 shows the measures of differentials between percentiles and inequality indicators. By comparing 1996/2006 factual with 1986/1996 counterfactual densities of benefits (96b87, 06b96), we notice there was a decrease in the differentials, that is, the increase in the share of beneficiaries raised the wage gap between the wealthy and the poor. On the other hand, the effect of contributions is a reduction in the gap. The Gini coefficient and Theil index corroborate in a more accurate way the distributive pattern of the social security system. The joint effect of taxes and benefit payments implies worsening of inequality as we compare 96bc87 to 1996, where the Gini coefficient (Theil index) increases from 0.5396 (0.5600) to 0.5581 (0.6037).

Table 8 summarizes the percentage change of the Gini coefficient and Theil index of factual and counterfactual densities. In the sample of individuals over 18 years old, the effect of benefits raises the Gini coefficient (Theil index) coefficient by 3.30% (7.23%) when comparing 1996 to 96b87 (the percentage is the ratio of factual and counterfactual densities) and raises *it by* 1.5% (1.49%) when comparing 2006 to 06b96. Since we have maintained the share of beneficiaries constant in the base year, we consider the effect of also fixing the share of taxpayers in the base year (by comparing, as an example, 96b87 to 96bc87 densities). Thus, the effect of contributions is almost none from 1987 to 1996 (0.14% [Gini] and 0.54% [Theil]) and progressive from 1996 to 2006 (-1.81% [Gini] and -3.86% [Theil]). By maintaining all social security rules constant in the base year (b and c at the 1987 level), the effect of other factors[29] is almost none from 1986 to 1996 (0.18% [Gini] and 0.71% [Theil]) and regressive for the next period (1.42% [Gini] and 4.14% [Theil]).

The estimations of counterfactual densities corroborate the distributive pattern of income distribution of the Brazilian social security system in the last decades. Both components of the social security structure (taxes and benefit payments) provide a raise in inequality[30] between 1987 and 1996. It means the system has become more regressive. In the last decade (1996-2006), both effects are in the opposite direction and hence the joint effect is almost none for inequality. That is, the system has not featured any trend towards increasing progressivity/regressivity; it has remained almost unchanged.

5.1 Sequential Decomposition in Reverse Order

So far, we have evaluated the effect of taxes and benefit payments followed by the effect of other attributes. However, the results can be altered if we have a reverse order of the effects. To perform the sequential decomposition in reverse order, that is, altering x, c and b, respectively, we apply the procedure described in the previous section, but in reverse order, following DFL (we have to estimate $\Psi_{x|c,b}(x,c,b)$, $\Psi_{c|b}(c,b)$ and $\Psi_b(b)$). Thus:

$$\Psi_b(b) = \frac{dF(b|t_b = 87)}{dF(b|t_b = 96)} \overset{\text{Bayes' Rule}}{=} \frac{\Pr(t_b = 87|b)}{\Pr(t_b = 96|b)} \frac{\Pr(t_b = 96)}{\Pr(t_b = 87)}$$

[29] The percentage was omitted, but can be easily verified by dividing 96bc87 by 96bcx87 and 06bc96 by 06bcx96.

[30] The effect can be approximately measured as the sum of percentages of Table 8. For example, under normal decomposition, the effect of benefits (3.30%) and taxes (0.14%) from 1987 to 1996 would be 3.44%. We consider this percentage sum as we discuss the total effect of Social Security legislation for benefits and taxes.

can be estimated as $\Psi_x(x)$, replacing x with b. The term $\Psi_{c|b}(b,c)$ defined as:

$$\begin{aligned}\Psi_{c|b}(c,b) &\equiv dF(c|b,t_{c|b}=87)/dF(c|b,t_{c|b}=96) \\ &= c\frac{\Pr\left(c=1|b,t_{c|b}=87\right)}{\Pr(c=1|b,t_{c|b}=96)}+(1-c)\frac{\Pr\left(c=0|b,t_{c|b}=87\right)}{\Pr(c=0|b,t_{c|b}=96)},\end{aligned}$$

is estimated analogously as in (4),) with a probit model, dependent variable c and independent variable b. To estimate $\Psi_{x|c,b}(x,c,b)$, we know that: $F(b,c,x) = F(b|c,x)F(c|x)F(x) = F(x|c,b)F(c|b)F(b)$. By applying the Bayes'rule, we have:

$$\widehat{\Psi}_{x|c,b}(x,c,b) = \frac{\widehat{\Psi}_{b|c,x}(b,c,x)\,\widehat{\Psi}_{c|x}(c,x)\,\widehat{\Psi}_x(x)}{\widehat{\Psi}_{c|b}(c,b)\,\widehat{\Psi}_b(b)},$$

where the numerator and $\widehat{\Psi}_b(b)$ have already been calculated during the normal decomposition and the term $\widehat{\Psi}_{c|b}(c,b)$ is obtained as above.

Reverse decomposition results Table 6 shows the results for the sequential decomposition in reverse order and Table 8 displays the percentage change in the right column. If we consider the effect of maintaining other factors[31] constant at the base year level, we find a higher increase in the Gini coefficient (Theil index) of 4.58% (10.77%) from 1987 to 1996 and a slightly lower raise in the next decade (1.06% [Gini] and 1.46% [Theil]). Still considering the whole sample (individuals aged over 18 years), taxes and benefit payments have little effect on the two decades as all attributes are constant at the base year level.

And by keeping other attributes, share of beneficiaries and taxpayers constant at the base year level, the total effect is the deterioration in income inequality. The Gini coefficient (Theil index) increased 3.63% (8.57%) from 1986 to 1996 (when comparing 1996 to 96xcb87) and 1.08% (1.61%) in the next 10 years (when comparing 2006 to 06xcb96). So, changes in individual attributes such as education, marital status, race, age group, working hours and geographical variables, have shown an increasing regressivity in the distribution of family income per capita.

From normal decomposition to sequential decomposition in reverse order, the social security system seems to be less regressive, especially when comparing the 1987-1996 period. This results from the conditioning of other factors (variables x), which explain most of the evolution of inequality over the years and reduce the potential effect of social security on the distribution.

Some variability in b and c is due to the variability of x. As an example, the demographic changes (variable age in x) imply a higher increase in the number of beneficiaries. If we keep demographic changes at the 1987 level, we raise the proportion of young people and reduce some reasonable effect of benefits, since young people have a lower probability to receive benefits as the probability of being a taxpayer has changed too little in the period (Table 1).

[31] The effect is obtained, for example, by the ratio of the Gini coefficient (Theil index) from 1996 and 96x87 densities, respectively. The percentage was omitted, but can be easily verified by the ratios of 1996/96x87 from Table 6.

5.2 Analysis of age structure

To consider the intergenerational distributive pattern of the social security system, we reestimate factual and counterfactual densities by age groups. Table 7 summarizes the results of the Gini/Theil coefficients and Table 8, the percentage change for both decompositions.

The joint effect of taxes and benefit payments from 1987 to 1996 (sum of the percentages of 1996/96b87 and 96b/96bc87 ratios) indicates an increase in regressivity for all ages (except for the age of 58-67 years), especially for the oldest (over 68 years old). Nonetheless, in regard to years 1996-2006, there has been a transition in the trend (for the sum of percentages of 2006/06b96 and 06b96/06bc96 ratios) for the youngest group (18-37) and the oldest group (68+). The 38-57-year-old cohort continues featuring bad inequality, while the 58-67-year-old cohort shows a reverse trend in relation to the last decade. The same occurs for the effect of contributions, except for the 58-67-year-old cohort. Thus, individuals over 68 years old in 2006 were in a better position than the ones in 1996, who were worse than individuals in 1986, due to the changes in social security rules. The same reasoning applies to young people.

We also applied the analysis for sequential decomposition in reverse order for age structure (right columns in Table 8). The distributive effects of changes in social security rules, given the change in other factors, tend to be relatively small for the 48-57-year-old cohort. For the 58-67-year-old cohort, the total effect (benefits and tax payments) increased progressivity for the 1987-1996 period and goes from increasing regressivity to stable for the 1996-2006 period. For individuals aged over 68 years, the total effect (benefits and contributions) increased progressivity for the 1987-1996 period and goes from increasing regressivity to stable for the 1996-2006 period. The Gini coefficient (Theil index) decreased up to 2.10% (3.41%) for this cohort in the 1987-1996 analysis, but the effect was less than 0.5% for the last decade.

In general, even when the effect of benefits and contributions was conditioned on variable x, there was an improvement in inequality for the oldest cohorts from 1987 to 1996, but this trend disappeared from 1996 to 2006.

5.3 Comments

Ferreira (2006) and also other authors have already pointed out some of the reasons for the increasing regressivity in the Brazilian social security system under normal decomposition, such as early age retirement, higher life expectancy, and higher wages for high-income beneficiaries. Gokhale & Kotlikoff (2002a and 2002b), Gohale et al. (2001) and Tafner & Giambiagi (2007) highlight the contribution ceiling.

Table 9 displays the ceiling for contributions: it used to be 20 times the regional minimum wage until 1984. After that, it became 20 times the federal minimum wage. In 1989, the ceiling decreased to 10 times the minimum wage and nowadays it is around 8 times the minimum wage (see footnote in the table). So, high-income individuals pay proportionally less. Since 1989, a higher number of high-income individuals has been paying less. This might have contributed to the increasing regressivity in the system by the end of the 1980s and half of the 1990s.

In terms of decomposition in reverse order, the social security system shows stable distributive effects. According to Liebman (2002) and Tafner & Giambiagi (2007), social security implies redistribution that is not related only to income (that is, income redistribution from the wealthy to the poor), as emphasized by normal decomposition analysis. Under the decomposition in reverse order, social security also implies redistribution among people with different individual attributes. Therefore, the joint effect of these attributes (variable x) implies stability of the distributive effects over the years. For example, income transfer from individuals with less schooling years to those with more education, from non-whites to whites, from single to married couples, and from rural to urban residences has not increased.

On the one hand, normal decomposition can be interpreted as follows: in terms of inequality, individuals who earn according to the 1996 (2006) wage level with individual attributes (education, working hours, age, etc) compatible with year 1996 (2006) and who live according to the 1996 (2006) social security rules are worse (equal) when compared to the same individuals living according to the 1987 (1996) social security rules. On the other hand, under the decomposition in reverse order, individuals who earn according to the 1996 (2006) wage level with individual attributes compatible with year 1987 (1996) and who live according to the 1987 (1996) wage level are stable when compared to the same individuals living according to the 1996 (2006) social security rules

Therefore, our preferred estimates are those of the sequential decomposition in reverse order. From normal decomposition to sequential decomposition in reverse order, the social security system seems to be less regressive, especially when comparing the 1987-1996 period. This results from the conditioning of other factors (variables x), which explain the evolution of inequality over the years and reduce the potential effect of social security on the distribution.

Our conclusion is that the Brazilian social security system implies income distribution that is not related only to income, but also to individual attributes. Further research is needed to verify the most influential causes for the increase in the regressivity of the Brazilian social security system.

6 Concluding Remarks

In this paper, we conclude that the Brazilian social security system has a distributive pattern throughout the period of analysis. Only when taxes and benefit payments were kept constant at the 1987 level did the system become less progressive. In other words, between 1987 and 1996, the changes in retirement rules (captured by the share of beneficiaries and taxpayers) contributed to increasing the regressivity of the system. However, when the variables (x) related to individuals and to geographical attributes were kept constant at the base year level, the effect of taxes and benefit payments became stable for the whole sample. In the last decade, from 1996 to 2006, both decompositions showed a trend towards stability.

However, the intergeneration analysis (for age groups) shows that, in general, even after conditioning on the variable x, there was a trend towards reducing inequality for the oldest cohorts (58+) from 1987 to 1996. But this trend disappeared from 1996 to 2006. For the other groups, the retirement system seems to be stable for both pairs of two-year periods analyzed.

For this reason, in opposition to some of the previous literature, the results reveal that retirement systems are not a good policy instrument for income redistribution. Therefore, in spite of the fact that PAYG systems, such as the Brazilian one, contribute to reducing poverty levels, there seems to be a growing need for reforms in countries that adopt this system. In Brazil, the Social Security Reform was partly accomplished in 2003, by reducing and postponing the insolvency trap. Besides, social security systems tend to be inefficient. De Carvalho Filho (2008) showed one of these inefficiency dimensions when studying the establishment of new retirement benefits (or increasing those which already exist) and the reduction of the minimum age for retirement, in 1991, for Brazilian rural workers. This study concluded that the 1991 Law had a negative impact on the decision to participate in the labor market, because it increased the probability of not working, and it reduced the total number of working hours.

In conclusion, the ample evidence presented in this paper suggests that the Brazilian social security system is not suitable for producing a higher level of equity. In other words, PAYG systems are not adequate policy tools for income redistribution, as some of the literature suggests. In view of the results we conclude that the Brazilian PAYG system has a high cost for the Brazilian economy.

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7 Appendix A

Table 1. Characteristics of Beneficiaries and Taxpayers in the Brazilian Social Security System

Social Security Benefits [(1)]				Social Security Taxes [(2)]			
Statistics	1987	1996	2006	Statistics	1987	1996	2006
Number of beneficiaries (in millions)				**Number of contributors (in millions)**			
Retirement	7.59	11.18	14.66	Worker	21.77	21.44	31.67
Pension	2.47	4.95	8.28	Civil Servant	2.20	4.21	5.50
Nonretirement allowance	0.04	0.01	0.01	Houseworker	0.67	1.18	1.86
				Autonomous worker	2.86	2.78	2.74
Total	10.10	16.13	22.95	Total	27.50	29.61	41.78
Share of each type of benefit				**Share of each type of taxpayer**			
Retirement	75.17%	69.31%	63.86%	Worker	79.16%	72.41%	75.81%
Pension	24.48%	30.66%	36.10%	Civil Servant	8.01%	14.21%	13.17%
Nonretirement allowance	0.35%	0.03%	0.04%	Houseworker	2.43%	3.97%	4.46%
				Autonomous worker	10.40%	9.40%	6.56%
Share of beneficiaries within each age group				**Share of taxpayers within each age group**			
18-27 years old	0.58%	1.47%	2.40%	18-27 years old	36.39%	32.08%	34.50%
28-37 years old	2.04%	3.22%	4.03%	28-37 years old	45.31%	42.21%	44.83%
38-47 years old	23.39%	17.84%	35.61%	38-47 years old	41.56%	42.42%	44.06%
48-57 years old	19.52%	24.00%	20.56%	48-57 years old	30.29%	30.02%	35.05%
58-67 years old	44.24%	60.44%	60.73%	58-67 years old	16.28%	14.15%	14.69%
68+ years old	83.45%	88.43%	87.67%	68+ years old	2.98%	2.56%	2.20%

Source: PNAD/IBGE

Note: [(1)] Social Security Benefits are divided into 3 categories: retirement, pension and abonement. The latter consists of government concession (25% of Social Security benefit) to keep the worker in the labor market, even though he (she) has all the requirements to retire.

[(2)] Taxes are divided according to the worker's occupation in the productive activity: worker, civil servant, houseworker and autonomous worker.

Table 2. Factual and counterfactual inequality index and counteractual-factual ratios in the analyzed sample

Age	Year	Factual		Counterfactual (1)		Counterfactual (2)		Counterfactual (3)		Ratios (1)/Factual		Ratios (2)/Factual		Ratios (3)/Factual	
		Gini	Theil	Gini	Theil	Gini	Theil	Gini	Theil	Gini	Theil	Gini	Theil	Gini	Theil
over 18 years old	1987	0.6005	0.7520	0.6220	0.8148	0.6027	0.7513	0.6244	0.8140	3.6%	8.4%	0.4%	-0.1%	4.0%	8.2%
	1996	0.5908	0.7073	0.6343	0.8264	0.5901	0.7005	0.6334	0.8176	7.4%	16.8%	-0.1%	-1.0%	7.2%	15.6%
	2006	0.5453	0.6042	0.6026	0.7505	0.5475	0.6043	0.6058	0.7512	10.5%	24.2%	0.4%	0.0%	11.1%	24.3%
18 - 27 years old	1987	0.5680	0.6617	0.5756	0.6858	0.5708	0.6638	0.5786	0.6879	1.3%	3.6%	0.5%	0.3%	1.9%	4.0%
	1996	0.5682	0.6436	0.5850	0.6900	0.5680	0.6380	0.5850	0.6838	3.0%	7.2%	0.0%	-0.9%	3.0%	6.2%
	2006	0.5296	0.5579	0.5499	0.6117	0.5327	0.5594	0.5537	0.6139	3.8%	9.6%	0.6%	0.3%	4.6%	10.0%
28 - 37 years old	1987	0.6072	0.7534	0.6139	0.7740	0.6095	0.7532	0.6162	0.7734	1.1%	2.7%	0.4%	0.0%	1.5%	2.7%
	1996	0.5941	0.7012	0.6097	0.7440	0.5932	0.6940	0.6085	0.7354	2.6%	6.1%	-0.2%	-1.0%	2.4%	4.9%
	2006	0.5553	0.6178	0.5761	0.6705	0.5592	0.6219	0.5802	0.6744	3.7%	8.5%	0.7%	0.7%	4.5%	9.2%
38 - 47 years old	1987	0.6018	0.7383	0.6148	0.7759	0.6045	0.7396	0.6175	0.7766	2.2%	5.1%	0.5%	0.2%	2.6%	5.2%
	1996	0.5983	0.7237	0.6209	0.7884	0.5971	0.7154	0.6193	0.7779	3.8%	9.0%	-0.2%	-1.1%	3.5%	7.5%
	2006	0.5460	0.5972	0.5762	0.6725	0.5495	0.5996	0.5795	0.6736	5.5%	12.6%	0.6%	0.4%	6.1%	12.8%
48 - 57 years old	1987	0.6087	0.7910	0.6342	0.8815	0.6102	0.7877	0.6361	0.8770	4.2%	11.5%	0.2%	-0.4%	4.5%	10.9%
	1996	0.6011	0.7313	0.6446	0.8684	0.6004	0.7253	0.6437	0.8593	7.2%	18.7%	-0.1%	-0.8%	7.1%	17.5%
	2006	0.5511	0.6277	0.6092	0.7888	0.5532	0.6266	0.6116	0.7852	10.5%	25.7%	0.4%	-0.2%	11.0%	25.1%
58 - 67 years old	1987	0.6271	0.8282	0.6889	1.0422	0.6287	0.8285	0.6906	1.0402	9.9%	25.8%	0.3%	0.0%	10.1%	25.6%
	1996	0.5871	0.7035	0.7103	1.0766	0.5875	0.7009	0.7098	1.0680	21.0%	53.0%	0.1%	-0.4%	20.9%	51.8%
	2006	0.5361	0.5909	0.6936	1.0354	0.5380	0.5920	0.6953	1.0319	29.4%	75.2%	0.3%	0.2%	29.7%	74.6%
68+ years old	1987	0.6495	0.9777	0.7752	1.4684	0.6511	0.9743	0.7755	1.4547	19.3%	50.2%	0.2%	-0.3%	19.4%	48.8%
	1996	0.5911	0.7527	0.7965	1.4664	0.5917	0.7508	0.7957	1.4550	34.7%	94.8%	0.1%	-0.3%	34.6%	93.3%
	2006	0.4921	0.5108	0.7531	1.2517	0.4937	0.5111	0.7544	1.2477	53.0%	145.0%	0.3%	0.1%	53.3%	144.3%

Note: (1) = worker's net earnings of all family members, in per capita terms - Social Security benefits

(2) = worker's net earnings of all family members, in per capita terms + Social Security taxes

(3) = worker's net earnings of all family members, in per capita terms - Social Security benefits + Social Security taxes

Table 3. Contingency Matrix and Adjustment Measures for Estimated Probits in Equation **(4)**

Dependent variable: share of beneficiaries - Sample: over 18 years old

		Year 1987			Year 1996			Year 2006		
		Real Value [1]			Real Value [1]			Real Value [1]		
		b	nb	Total	b	nb	Total	b	nb	Total
Classified as [2]										
+		13794	3159	16953	22167	5175	27342	29787	7483	37270
-		7227	143975	151202	11454	157905	169359	16883	208949	225832
Total		21021	147134	168155	33621	163080	196701	46670	216432	263102
Sensitivity	Pr(+| b)		65.62%			65.93%			63.82%	
Specificity	Pr(-|nb)		97.85%			96.83%			96.54%	
Positive predictive value	Pr(b| +)		81.37%			81.07%			79.92%	
Negative predictive value	Pr(nb| -)		95.22%			93.24%			92.52%	
False + rate for true nb	Pr(+|nb)		2.15%			3.17%			3.46%	
False - rate for true b	Pr(-| b)		34.38%			34.07%			36.18%	
False + rate for classified +	Pr(nb| +)		18.63%			18.93%			20.08%	
False - rate for classified -	Pr(b| -)		4.78%			6.76%			7.48%	
Correctly classified [3]			93.82%			91.55%			90.74%	
Goodness-of-fit test										
Number of observations			168155			196701			263102	
Pearson Statistics			787170			556183			429858	
Prob > Pearson Statistics			0.0000			0.0000			0.0000	
Predictive Power Measure										
Area under ROC curve[4]			0.9511			0.9383			0.9289	

Note:[1] Real Value is the observed value in the sample. The individual is a beneficiary (b) or not (nb), being assigned values 1 and 0, respectively. [2] The model classifies an individual as beneficiary (+) if the projected probability from probit (Pr(b|c,x)) is higher than or similar to a cutoff (equal to 0.5 for values shown in the matrix at the top of the table). [3] Correctly classified indicator is calculated by the sum of the main diagonal in the matrix divided by the total. [4] ROC curve (*receiver operating characteristic*) is the ratio of the probability of a positive test result if the outcome is positive (true positive or sensitivity) to the probability of a positive test result if the outcome is negative (false positive or 1 - specificity) when the cutoff varies from 0 to 1. The area under ROC curve is a predictive power measure of the estimated model, varying from 0.5 (no predictive power) until 1 (perfect predictive power).

Table 4. Contingency Matrix and Adjustment Measures for Estimated Probits in the Equation **(5)**
Dependent variable: share of taxpayers **-** *Sample: over 18 years old*

		Year 1987			Year 1996			Year 2006		
		Real Value [(1)]			Real Value [(1)]			Real Value [(1)]		
		c	nc	Total	c	nc	Total	c	nc	Total
Classified as [(2)]										
+		43791	15337	59128	41484	18269	59753	61115	25692	86807
-		15700	93327	109027	23312	113636	136948	28044	148251	176295
Total		59491	108664	168155	64796	131905	196701	89159	173943	263102
Sensitivity	Pr(+| c)		73.61%			64.02%			68.55%	
Specificity	Pr(-|nc)		85.89%			86.15%			85.23%	
Positive predictive value	Pr(c| +)		74.06%			69.43%			70.40%	
Negative predictive value	Pr(nc| -)		85.60%			82.98%			84.09%	
False + rate for true nb	Pr(+|nc)		14.11%			13.85%			14.77%	
False - rate for true b	Pr(-| c)		26.39%			35.98%			31.45%	
False + rate for classified +	Pr(nc| +)		25.94%			30.57%			29.60%	
False - rate for classified -	Pr(c| -)		14.40%			17.02%			15.91%	
Correctly classified [(3)]			81.54%			78.86%			79.58%	
Goodness-of-fit test										
Number of observations			168155			196701			263102	
Pearson Statistics			164033			164189			216214	
Prob > Pearson Statistics			0.0000			0.0000			0.0000	
Predictive Power Measure										
Area under curve ROC[(4)]			0.8934			0.8719			0.8782	

Note: [(1)] Real Value is the observed value in the sample. The individual is a taxpayer (c) or not (nc), being assigned values 1 and 0, respectively. (2) The model classifies an individual as taxpayer (+) if the projected probability from probit (Pr(b|c,x)) is higher than or similar to a cutoff (equal to 0.5 for values shown in the matrix at the top of the table). [(3)] Correctly classified indicator is calculated by the sum of the main diagonal in the matrix divided by the total. [(4)] ROC curve (*receiver operating characteristic*) is the ratio of the probability of a positive test result if the outcome is positive (true positive or sensitivity) to the probability of a positive test result if the outcome is negative (false positive or 1 - specificity) when the cutoff varies from 0 to 1. The area under ROC curve is a predictive power measure of the estimated model, varying from 0.5 (no predictive power) until 1 (perfect predictive power).

Table 5. Measures of Differentials between Percentiles and Inequality Indicators for Densities (Normal Decomposition)

Measures	1987	1996	2006	96b87	96bc87	96bcx87	06b96	06bc96	06bcx96
90-10	1011	1093	1044	978	1030	900	1236	1246	1010
50-10	183	191	233	181	196	170	233	237	201
90-50	828	902	811	796	835	730	1002	1009	809
75-25	394	416	422	379	403	362	460	464	387
95-5	1676	1815	1742	1507	1601	1432	2299	2525	2106
Gini	0.5668	0.5581	0.5432	0.5403	0.5396	0.5386	0.5352	0.5451	0.5374
Theil	0.6267	0.6037	0.5504	0.5630	0.5600	0.5560	0.5423	0.5641	0.5417

Note: Differentials between percentiles and the Gini/Theil coefficients obtained for 1987, 1996 and 2006 estimated densities, $f\left(w; t_{w|b,c,x} = t, t_{x|c,b} = t, t_{c|b} = t, t_b = t\right)$, where t is always one of those years. The counterfactual values were obtained from simulated counterfactual densities. For example, 96b87 refers to the differential between percentiles and Gini/Theil coefficients obtained for counterfactual density $f\left(w; t_{w|b,c,x} = 96, t_{x|c,b} = 87, t_{c|b} = 96, t_b = 96\right)$. 96bc87 refers to counterfactual density $f\left(w; t_{w|b,c,x} = 96, t_{x|c,b} = 87, t_{c|b} = 87, t_b = 96\right)$ 96bcx87 refers to counterfactual density $f\left(w; t_{w|b,c,x} = 96, t_{x|c,b} = 87, t_{c|b} = 87, t_b = 87\right)$. Analogously, the same pattern is valid when comparing 2006 and 1996.

Table 6. Measures of Differentials between Percentiles and Inequality Indicators for Densities (Sequential Decomposition in Reverse Order)

Measures	1987	1996	2006	96x87	96xc87	96xcb87	06x96	06xc96	06xcb96
90-10	1011	1093	1044	898	899	900	1010	1010	1010
50-10	183	191	233	170	171	170	198	204	201
90-50	828	902	811	728	728	730	812	807	809
75-25	394	416	422	362	363	362	388	385	387
95-5	1676	1815	1742	1388	1403	1432	2128	2149	2106
Gini	0.5668	0.5581	0.5432	0.5337	0.5351	0.5386	0.5375	0.5373	0.5374
Theil	0.6267	0.6037	0.5504	0.5450	0.5480	0.5560	0.5425	0.5413	0.5417

Note: Differentials between percentiles and the Gini/Theil coefficients obtained for 1987, 1996 and 2006 estimated densities, $f\left(w; t_{w|b,c,x} = t, t_{x|c,b} = t, t_{c|b} = t, t_b = t\right)$, where t is always one of those years. The counterfactual values were obtained from simulated counterfactual densities. For example, 96x87 refers to the differential between percentiles and Gini/Theil coefficients obtained for counterfactual density $f\left(w; t_{w|b,c,x} = 96, t_{x|c,b} = 87, t_{c|b} = 96, t_b = 96\right)$. 96xc87 refers to counterfactual density $f\left(w; t_{w|b,c,x} = 96, t_{x|c,b} = 87, t_{c|b} = 87, t_b = 96\right)$ 96xcb87 refers to counterfactual density $f\left(w; t_{w|b,c,x} = 96, t_{x|c,b} = 87, t_{c|b} = 87, t_b = 87\right)$. Analogously the same pattern is valid when comparing 2006 and 1996.

Table 7. Inequality Indicators for Densities (Normal and Sequential Decomposition in Reverse Order)

		Factual Densities			Counterfactual Densities											
					Normal Decomposition						Sequential Decomposition in Reverse Order					
Age group	Measures	1987	1996	2006	96b87	96bc87	96bcx87	06b96	06bc96	06bcx96	96x87	96xc87	96xcb87	06x96	06xc96	06xcb96
18-27	Gini	0.5495	0.5469	0.5380	0.5395	0.5338	0.5306	0.5406	0.5439	0.5259	0.5308	0.5308	0.5306	0.5256	0.5258	0.5259
years old	Theil	0.5748	0.5699	0.5344	0.5639	0.5507	0.5462	0.5509	0.5696	0.5241	0.5470	0.5470	0.5462	0.5241	0.5244	0.5241
28-37	Gini	0.5859	0.5640	0.5492	0.5555	0.5496	0.5505	0.5551	0.5645	0.5526	0.5489	0.5497	0.5505	0.5511	0.5517	0.5526
years old	Theil	0.6747	0.6206	0.5678	0.6058	0.5875	0.5933	0.5952	0.6174	0.5865	0.5891	0.5911	0.5933	0.5829	0.5843	0.5865
38-47	Gini	0.5916	0.5882	0.5451	0.5752	0.5632	0.5589	0.5365	0.5368	0.5334	0.5562	0.5578	0.5589	0.5343	0.5340	0.5334
years old	Theil	0.6857	0.6743	0.5546	0.6379	0.6056	0.5980	0.5433	0.5438	0.5360	0.5906	0.5950	0.5980	0.5386	0.5378	0.5360
48-57	Gini	0.5781	0.5843	0.5515	0.5743	0.5737	0.5621	0.5488	0.5451	0.5382	0.5599	0.5605	0.5621	0.5410	0.5397	0.5382
years old	Theil	0.6544	0.6679	0.5694	0.6402	0.6356	0.6038	0.5689	0.5603	0.5406	0.5978	0.5992	0.6038	0.5475	0.5443	0.5406
58-67	Gini	0.54539	0.4991	0.4869	0.4959	0.5047	0.4986	0.4870	0.4755	0.4575	0.4914	0.4855	0.4986	0.4571	0.4590	0.4575
years old	Theil	0.59796	0.4916	0.4515	0.4909	0.5106	0.4939	0.4521	0.4262	0.3851	0.4813	0.4713	0.4939	0.3846	0.3877	0.3851
68+	Gini	0.4815	0.4382	0.3804	0.4140	0.3306	0.3317	0.3915	0.3938	0.3839	0.3246	0.3206	0.3317	0.3830	0.3854	0.3839
years old	Theil	0.4902	0.3984	0.2866	0.3692	0.2234	0.2054	0.3048	0.3101	0.2909	0.1982	0.1950	0.2054	0.2896	0.2931	0.2909

Table 8. Increase/Decrease in Gini Coefficient and Theil Index due to the effect of share of beneficiaries and taxpayers from a base year to a specific year

Age	Index	Normal Decomposition				Sequential Decomposition in Reverse Order			
		1996/ 96b87	1996b/ 96bc87	2006/ 06b96	06b96/ 06bc96	96x87/ 96xc87	96xc87/ 96xcb87	06x96/ 06xc96	06xc96/ 06xcb96
18+	Gini	3.30%	0.14%	1.50%	-1.81%	-0.26%	-0.66%	0.04%	-0.02%
	Theil	7.23%	0.54%	1.49%	-3.86%	-0.56%	-1.44%	0.22%	-0.07%
18-27	Gini	1.37%	1.06%	-0.49%	-0.61%	0.01%	0.03%	-0.04%	-0.01%
	Theil	1.07%	2.40%	-2.99%	-3.27%	0.02%	0.14%	-0.06%	0.05%
28-37	Gini	1.53%	1.07%	-1.06%	-1.67%	-0.13%	-0.16%	-0.11%	-0.16%
	Theil	2.44%	3.11%	-4.60%	-3.59%	-0.33%	-0.38%	-0.25%	-0.38%
38-47	Gini	2.26%	2.13%	1.59%	-0.04%	-0.29%	-0.20%	0.06%	0.12%
	Theil	5.71%	5.33%	2.07%	-0.09%	-0.73%	-0.51%	0.15%	0.33%
48-57	Gini	1.74%	0.09%	0.49%	0.67%	-0.09%	-0.30%	0.24%	0.29%
	Theil	4.33%	0.72%	0.09%	1.54%	-0.22%	-0.76%	0.58%	0.68%
58-67	Gini	0.64%	-1.73%	-0.01%	2.40%	1.21%	-2.61%	-0.42%	0.34%
	Theil	0.15%	-3.87%	-0.14%	6.07%	2.12%	-4.58%	-0.81%	0.68%
68+	Gini	5.85%	25.20%	-2.83%	-0.58%	1.24%	-3.35%	-0.65%	0.39%
	Theil	7.92%	65.28%	-5.97%	-1.69%	1.67%	-5.07%	-1.20%	0.74%

Note: Increase/decrease in Gini coefficient and Theil index is calculated by dividing the ratio between factual indicator and counterfactual of benefit and tax for normal decomposition and the ratio between counterfactual indicator of other factors and counterfactual of other factors, benefit and tax. For example, the 1996/96b87 ratio considers the increase in Gini/Theil coefficients due to the effect of a change in the share of beneficiaries and taxpayers from 1987 to 1996. The 96x87/96xb87 ratio considers the increase in Gini/Theil coefficients due to the effect of a change in the share of beneficiaries and taxpayers from 1987 to 1996, given the change in other factors.

8 Appendix B

Social security rates were obtained from Afonso & Fernandes (2005) and the legislation is based on information from the website of the Brazilian Ministry of Social Security (Sistema de Legislação, Jurisprudência e Pareceres [SISLEX], www.dataprev.gov.br/sislex and www.mpas.gov.br). Employee's tax rates are in Table 9, according to each worker group. The taxes apply to the salary base, which is by definition the sum of earnings of all jobs in which an individual has worked.

Tax rates for ordinary workers before 1986 refer to the highest regional minimum wage (SMR) in force in Brazil at the time and are set by minimum and maximum intervals. That is, if earnings are under 1 SMR, taxed wage is 1 SMR and, analogously, if earnings exceed 20 times the SMR, taxed wage is 20 SMR. For houseworkers, there are no such limits and rates around 8% are applied to the SMR of the place where the worker lives and not to the highest SMR.

Since 1986, rates have been applied per earning group, considering minimum and maximum intervals (1 minimum wage - 1 SM and 20 minimum wages – 20 SM, respectively) for ordinary workers. For houseworkers, employee's rates are 8% on earnings, reflecting minimum and maximum intervals (1 and 2 SM, respectively). Employer's rates are 8% SM for any earnings level. In 1996 and 2006, ordinary workers and houseworkers were set under the same rates and in the same earnings groups.

Since 1989, the rates paid by enterprises in the financial sector have increased by 2.5%, which is equivalent to 22.5% of the total. Autonomous worker's rates should be applied to a base wage, which depends on the time of assessment. As information was not available, we calculated social security tax values endogenously, as Afonso & Fernandes (2005), that is, using the MPAS information, we divide the sum of individual taxes from insured individuals by the total of taxes. To obtain the employer's rate for autonomous workers, we divide the sum of taxes paid by enterprises by the total of social security revenue. The rate represents the effective rate of all enterprises. Then, using PNAD data, we obtain the share of autonomous taxpayers and multiply it by the rate of all enterprises in order to obtain a proxy for effective rate of the enterprise that is related to the autonomous worker. The rates are in the following Table 9 and are applied over PNAD earnings, with no restrictions. Since April 2003, the base wage is no longer used. The new nomenclature is taxed wage, which is the total of earnings from autonomous workers.

Besides, there is a compulsory complementary tax for the individual taxpayer if the discounted value per enterprise is less than the minimum limit in the taxed wage (20% of the difference). The exceeding value of the minimum limit (1 SM) has already been paid by the autonomous worker. Finally, the employer's rate for autonomous workers is 20%, if the enterprise is a charity that provides Social Assistance.

By assumption, we consider the civil servant's rate as 11% and there is no payment from the Government (Federal, State and municipalities), as adopted in Afonso & Fernandes (2005).

Table 9. Social Security Tax for Workers, according to Occupation in the Productive Activity

Income range	1987		
	Worker	Houseworker	Autonomous worker
1MW <= w <= 3 MW	8.5%	8%	7.64%
3 MW < w <= 5 MW	8.75%	-	7.64%
5 MW < w <= 10 MW	9%	-	7.64%
10 MW < w <= 15 MW	9.5%	-	7.64%
15 MW < w <= 20 MW	10%	-	7.64%

Income range	1986		
	Worker	Houseworker	Autonomous worker
1MW <= w <= 249.8	8%	8%	3.79%
249.8 < w <= 416.33	9%	9%	3.79%
416.33 < w <= 832.66	11%	11%	3.79%

Income range	2006		
	Worker	Houseworker	Autonomous worker
1MW <= w <= 840.55	7.65%	7.65%	20%
840.55 < w <= 1050	8.65%	8.65%	20%
1050 < w <= 1400.91	9%	9%	20%
1400.91 < w <= 2801.82	11%	11%	20%

Source: Data obtained from the Social Security Legislation.
Note: Income ranges are not in real terms. Minimum wage (MW) in 1996 was equivalent to 112 reais. Social Security tax ceiling (832.66) exceeded 7.44 times the minimum wage at that time. Minimum wage in 2006 was equivalent to 350 reais and tax ceiling (2801.82) exceeded the minimum wage about 8 times.