

Moving to a Consumption-Based Tax System: A Quantitative Assessment for Brazil*

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For many years, it has been a primary issue in tax policy whether the tax system ought to be built around income tax or consumption tax. Much of the interest in tax policy arises from the widespread belief that taxes on income and savings tend to lower long-run income by retarding the creation and expansion of firms and by discouraging workers and investments. Following this belief, Brazilian government has proposed a tax reform which, basically, replaces tax on investment and labor with tax on consumption. In this paper, we develop a dynamic general equilibrium model with heterogeneous agents to guide our quantitative assessment of the economic and distributional implications of such tax reform. The model is calibrated in such a way that it matches some selected features of the Brazilian economy. We also use the calibrated model to calculate the deadweight loss of each type of taxation and thus provide some rationality for that rearrangement in the tax system. The main result of the paper is that, even though the tax reform increases the asset accumulation, labor and output of economy, it also raises the welfare inequality as borrowing constrained individuals cannot take advantage of the drop in tax on savings.

Uma importante questão em política tributária é se o sistema de tributação deve ser construído com foco na taxação da renda ou do consumo.

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Muito do interesse em política tributária vem da disseminada crença que as taxas sobre a renda e a poupança tendem à reduzir o produto de longo prazo, retardando a criação e a expansão das firmas e desencorajando a oferta de trabalho e o investimento. Seguindo essa idéia, o governo brasileiro propôs uma reforma tributária a qual, basicamente, substitui a taxaço do investimento e do trabalho pela taxaço do consumo. Nesse artigo, nós desenvolvemos um modelo dinâmico de equilíbrio geral com agentes heterogêneos para investigar quantitativamente os efeitos econômicos e distributivos de tal reforma. O modelo é calibrado de forma a reproduzir selecionadas estatísticas da economia brasileira. Nós também usamos o modelo calibrado para calcular a perda de peso morto causada por cada tipo de tributação, o que permite analisar a racionalidade da mudança do sistema tributário proposta pelo governo. O principal resultado do artigo é que, embora a reforma tributária aumente a acumulação de capital, o emprego e o produto da economia, ela também aumenta a desigualdade, uma vez que, além da redução da regressividade do sistema, os indivíduos com baixa renda e que enfrentam restrição à crédito não se beneficiam da redução da taxaço da poupança.

1. INTRODUCTION

Brazilian economy has improved significantly in many dimensions over the last decade. Inflation continues to be under control and inflation expectations remain low. Brazil's external position is solid, with a strong current account surplus – about 2 percent of GDP in 2007 – and international reserves around \$201 billion, equivalent to more than 200 percent of its short-term debt. The fiscal adjustment since the floating of the Real in 1999 has been impressive, allowing the consolidation of macroeconomic stability in the period and ensuring that the dynamics of public indebtedness is sustainable.

Nevertheless, the fiscal adjustment has taken place on the back of revenue hikes and, to a lesser extent, a compression of public investment, rather than the retrenchment of current outlays. As a result, Brazil's tax-to-GDP ratio has increased almost ten percentage points over the last two decades and now it is much higher than that of countries with comparable income levels, being close to the OECD average and nearly twice as high as that of the rest of Latin America (De Mello, 2008).

This increase in the tax burden in Brazil has been pointed out as an important explanation for the unsatisfactory performance of the economy in terms of growth. Much of the interest in tax policy arises from the widespread belief that taxes on income and savings tend to lower long-run income by retarding the creation and expansion of firms and by discouraging workers and investment. The empirical evidence that come from, for example, Helms (1985), Mofidi e Stone (1990) and Slemrod (1999) suggests a significant effect of taxation on the economic performance, particularly over the long term.

Following this belief, Brazilian's government has submitted a constitutional amendment to the examination of the congress, which, among others changes, proposes a significant reduction of tax on investment and on labor income. However, the proposal will not change the tax burden in terms of GDP since it contains a provision which ensures the neutrality of the tax reform. Thus, the government's proposal ultimately entails a rearrangement of the current tax system in such way that it cuts taxes on investment and labor and offsets it by increasing tax on consumption.

The goal of the present analysis is to quantitatively assess the economic and distributional implications of this rearrangement in the tax system. To guide our assessment, we develop a dynamic general

equilibrium model with overlapping generations in line with Auerbach e Kotlikoff (1987) and Ríos-Rull (1996). The model economy considered in this paper is populated by a large number of agents who have preferences over consumption and leisure and face idiosyncratic productivity shocks. Individuals cannot insure directly against these shocks, but they can trade an asset subject to an exogenous lower bound on asset holdings. Following Aiyagari (1994), this asset takes the form of capital. Thus, savings may be precautionary and allow partial insurance against the idiosyncratic shocks. Because of the lack of full insurance, this model generates an endogenous distribution of wealth across consumers. Indeed, at any point in time, households differ in their current shock, in their asset holdings (that somehow summarizes all their past luck) as well as in terms of their age. We calibrate the model in such a way that it matches selected statistics of the Brazilian economy and then use the calibrated model to study many issues related with the tax reform proposed by the government.

First, we calculate the welfare cost due to each type of taxation. This is done by calculating the deadweight loss of taxes of raising extra revenues from an already existing distorting tax. An extensive literature has estimated the deadweight loss and it now is understood as being an important guide to design the fiscal policy.¹ Overall, however, this literature has focused on portions of the tax system such as tax on capital and labor income or its estimates are based on data from the U.S. economy. The model used in this paper, in contrast, is calibrated using data from Brazilian economy and, besides tax on capital and labor income, it takes into account tax on consumption and investment. As a consequence, the framework in this paper can be used to assess, for example, how much distortionary the tax on investment is and whether or not government should move towards consumption taxation in order to reduce the inefficiency associated with the tax system.

Second, given that individuals in our model face uninsured idiosyncratic shocks of productivity, wealth accumulation in this class of models is higher than when there is no uncertainty,² as individuals react to the uncertainty regarding to their future labor income by reducing current consumption and increase savings.³ As it will turn out, this over accumulation may play an important role in determining the welfare cost of taxes.

Furthermore, we measure the long-run impact of the tax reform on the aggregate variables of the model economy such as output, capital accumulation, hours worked in order to document the potential economic gains that can be obtained with the reduction of the distortions caused by the taxation of capital and labor. This assessment is important because proponents of the reform argue that its positive effects on those variables are expected to be of considerable magnitude and, as a consequence, the shift towards a consumption-based tax system is viewed as highly desirable.

Finally, by calibrating the income distribution in the model in such a way that it matches the income inequality as measured by Gini index, our framework is also useful to address the distributional implications of the tax reform, an issue that has not been fully analyzed yet. The assessment of the distributional effects of the type of reform proposed by the government is especially important in Brazil because tax on consumption is strongly regressive. This is so because individuals at low levels of the income distribution spend the most part of their income on consumption and many of them do not save at all, whereas those at high levels of the income distribution save the most part of their income. A tax reform which, for example, replaces tax on investment with tax on consumption improves the situation of the richer individuals and may worsen the situation of the poorer ones. This latter effect is due to the fact that, even though that reform may increase the per capita income of economy, the increase in tax on consumption may be even higher, and thereby it can negatively impact on the welfare of the poorer individuals. Therefore, the tax reform can adversely affect the cross-sectional welfare distribution.

Feenberg et alii (1997), using data from the U.S. tax system, carry out an analysis of distributional tables to investigate the effects of replacing tax on income with tax on consumption on the welfare

¹See, for example, Browning (1987), Hansson (1984), Balland et alii (1985), Judd (1998), McGrattan (1994) and Feldstein (1997).

²See, for example, Kimball (1990), Deaton (1991) and Carroll (1997).

³As long as utility function is increasing, concave and has a positive third derivative.



distribution. Even though they conclude it could increase the welfare inequality, their approach faces with many shortcomings associated with the absence of general equilibrium feedback effects, which may play an important role in the assessment of the distributional impacts of the tax reform. This paper, in contrast, uses a dynamic general equilibrium model, and thereby we are able to take into account, for example, the response of individuals to the changes in the tax system.

Pereira e Ferreira (2009) have also investigated the economic impacts of changes in the tax system in Brazil. They rely on the representative-agent abstraction to evaluate how the tax reform affect the output, capital, labor and individuals welfare. However, given that their model economy behaves as if it is inhabited by a single type of consumer, the framework used in that paper is not suitable for addressing the distributional implications of the reform, which is a major point in the present analysis. Moreover, they implicitly assume that there are complete insurance markets for consumers' idiosyncratic risks, which is an assumption hard to defend (Aiyagari, 1994).

Besides this Introduction, this paper is organized as following. In Section 2, we present the model which will be used to guide our quantitative assessment. In Section 3, the data and calibration procedures are described. In Section 4, we discuss the main results. Section 5 concludes.

2. THE MODEL

2.1. Demography

The economy is populated by a continuous of mass one agents that can live to a maximum of T periods. There is uncertainty regarding the time of death, each individual faces a probability ψ_t of dying in the age t . The age profile of the population $\{\mu_t\}_{t=1}^T$ is modeled assuming that the fraction of agents at the age t in the population is given by $\mu_t = \frac{\psi_t}{(1+g_n)}\mu_{t-1}$ and $\sum_{t=1}^T \mu_t = 1$, where g_n denotes the population growth rate.

2.2. Preferences

Each individual maximizes the discounted expected utility throughout life:

$$E \left[\sum_{t=1}^T \beta^{t-1} \left(\prod_{k=1}^t \psi_k \right) u(c_t + \sigma G_t, 1 - h_t) \right] \tag{1}$$

where β is the discount factor and E is the expectation operator. The utility function of each period is assumed to take the form:

$$u(c_t, 1 - h_t) = \frac{[(c_t + \sigma G_t)^{1-\rho}(1 - h_t)^\rho]^{1-\gamma}}{1 - \gamma} \tag{2}$$

where γ denotes the risk aversion parameter and ρ denotes share of leisure in the utility.

The specification in equation (2) assumes that, besides consumption c_t and leisure $(1 - h_t)$, the household's utility is also influenced by the government expenditures if $\sigma \neq 0$. If $\sigma < 0$, the marginal utility of consumption increases with an increase in G and if $\sigma > 0$, the opposite meaning is true. Thus, our framework allow for substitutability or complementarity between public and private goods.

2.3. Technology

The technology of production of the economy is given by a Cobb-Douglas function with constant returns to scale, $Y_t = BK_t^\alpha (A_t N_t)^{1-\alpha}$ where α is the capital share and Y, K, N and $B > 0$ denote aggregate output, capital, labor and a scale parameter, respectively. The variable A_t denotes a labor

augmenting productivity index that grows at a constant rate g_A . The problem of the firms is standard, that is, they pick capital and labor optimally in order to solve:

$$\max_{K_t, N_t} BK_t^\alpha (A_t N_t)^{1-\alpha} - wN_t - rK_t \quad (3)$$

Capital and labor services are paid by their marginal products, i.e.,

$$r = \alpha B \left(\frac{K}{AN} \right)^{\alpha-1} \quad (4)$$

$$w = (1 - \alpha) BA \left(\frac{K}{AN} \right)^\alpha \quad (5)$$

where r denotes the net rate of return on capital and w the wage.

2.4. The government budget

Government expenditures G_t are assumed to be a certain constant fraction θ of output of economy Y_t . To finance its stream of expenditures, we also assume that government has access to a set of fiscal instruments. This set of instruments available consists of proportional taxes on consumption τ_c , labor τ_w , capital τ_k and investments τ_i . Moreover, it is assumed that the government does not have debt, so that its budget constraint can be written as following:

$$\tau_c C_t + \tau_i I_t + \tau_w r K_t + \tau_k w N_t = G_t = \theta Y_t \quad (6)$$

where C_t , I_t , K_t and N_t denote the aggregate consumption, investment, capital and labor, respectively.

Note that the government does not directly control the set of taxes $\{\tau_c, \tau_w, \tau_k, \tau_i\}$, since it is assumed to be endogenously determined. What the government controls, indeed, is how the total amount of revenue needed to finance its expenditures is split into those sources. Let θ_m with $m \in \{c, w, k, i\}$ be the share of government's revenue due to tax on the source m , so that $\theta = \sum_m \theta_m$ which denotes the tax burden of economy. Thus, the set of taxes is given by:

$$\tau_c = \theta_c \frac{Y_t}{C_t}, \tau_w = \theta_w \frac{Y_t}{wN_t}, \tau_k = \theta_k \frac{Y_t}{rK_t}, \tau_i = \theta_i \frac{Y_t}{I_t} \quad (7)$$

Inasmuch as the distribution is determined by the production function, the taxes τ_w and τ_k are given exogenously by the technology of economy and by the fiscal policy. Moreover, if the government reduces θ_i and for example, increases θ_c in order to keep the tax burden unchanged, the equations in (7) can be used to estimate the taxes τ_c and τ_i in the new equilibrium.

We use the formulation in (7), instead of assuming taxes to be exogenous, because C/Y and I/Y are endogenous and thereby they are expected to change as the tax reform takes place. As a consequence, we do not know in advance what tax should be levied in order to keep the tax burden in terms of GDP unchanged. By using the formulation in (7), the taxes are endogenously determined, along with C/Y and I/Y and other endogenous variables of the model.

2.5. Individuals' budget constraints

In this economy, individuals make decisions about their labor supply h_t and savings a_t . At the beginning of each period, they face idiosyncratic shocks z on their labor productivity. We assume that z is a random variable which follows a first order auto-regressive process $\ln z_t = \pi \ln z_{t-1} + \varepsilon_t$, where $\varepsilon_t \sim N(0, \sigma_\varepsilon^2)$. In addition, the labor productivity of individuals also depends on an age-efficiency component \bar{y}_t . Let $e_t(z, \bar{y}_t)$ denote the labor productivity of an individual at age t so that the labor income after tax is given by $y_w(z, t) = (1 - \tau_w) w h_t e_t(z, \bar{y}_t)$.



Each period, individuals purchase consumption c_t and investment goods i_t with their after-tax income, which is obtained by renting the factors of production that they own to the firms. The capital income after-tax is $(1 - \tau_k)ra_t$, where a_t denotes the asset holdings. Individuals are price-takers and the price of consumption and investment goods are normalized to 1. The final source of income is the accidental bequest transfers ξ . Thus, an individual's budget constraint can be written as following:

$$(1 + \tau_c)c_t + (1 + \tau_i)i_t = r(1 - \tau_k)a_t + y_w(z, t) + \xi \quad (8)$$

The investment i_t is determined by the law of motion for asset accumulation, that is:

$$i_t = (1 + g_A)a_{t+1} - (1 - \delta)a_t \quad (9)$$

where $(1 + g_A)a_{t+1}$ denotes the asset holdings in the next period, taking into account the technological progress g_A , and $(1 - \delta)a_t$ is the current asset stock after applying the depreciation rate δ .

Given that we are going to focus on the state steady of the economy under study, we have divided consumption, asset holdings, lump sum transfers and wage rate by A_t in order to eliminate the effect of economic growth. This transformation accounts for the term $(1 + g_A)a_{t+1}$ in (9).

In this economy, there is no private market for insurance against the risk from the shocks on labor productivity or from living longer than expected. Additionally, we assume that individuals are liquidity constrained and set the restriction of assets carried over from age t to $t + 1$ to be $a_{t+1} \geq 0 \forall t$. As it will turn out, liquidity constraints tend to play an important role in determining the results of some simulations that will be carried out in this paper. This is so because individuals who are liquidity constrained tend to be more affected by a tax reform which increases the tax on consumption.

Given that there is no altruistic bequest motive and death is certain after age T , an agent who reached age T will consume all his assets at that age, so that we have $a_{T+1} = 0$.

2.6. Equilibrium

Let s denote the individual states. It depends on the asset holdings a at the beginning of the period and on the idiosyncratic shock z so that $s = (a, z)$. Let $V_t(s)$ denote the value function of an agent age t . The value functions $V_t(s)$ are defined by the following dynamic programs:

$$V_t(s) = \max_{h, a'} \{u(c, 1 - h) + \beta \psi_{t+1} E_z V_{t+1}(s')\} \quad (10)$$

subject to (8)

where $s' = (a', z')$ and $\psi_{t+1} = \prod_{k=1}^{t+1} \psi_k$.

Suppose $A \subset R_+$ and $Z \subset R$, are the sets of possible values that a and z can take, so that we can define the state space as $S = A \times Z$. Let $g_t : S \rightarrow R_+$ and $n_t : S \rightarrow [0, 1]$ be the policy functions associated with a' and h in the dynamic programs above.

At each point of time, agents are heterogeneous in regard to age t and to state $s \in S$ and, as a consequence, we need some way of describing this heterogeneity. The agents' distribution at age t among the states s is represented by a measure of probability λ_t defined on subsets of the state space S . Let $(S, \Omega(S), \lambda_t)$ be a space of probability, where $\Omega(S)$ is the Borel σ -algebra on S . Thus, for each $\omega \subset \Omega(S)$, we have that $\lambda_t(\omega)$ denotes the agents' fraction at age t that are in ω .

The transition from age t to age $t + 1$ is governed by the transition function $Q_t(s, \omega)$, which depends on the decision rule $g_t(s)$ of assets and on the realization of the idiosyncratic productivity shock z . The function $Q_t(s, \omega)$ gives the probability of an agent at age t and state s to transit to the set ω at age $t + 1$.

Thus, a recursive competitive equilibrium for this economy can be defined as following:

Definition 2.1. Given the policy parameters, a recursive competitive equilibrium for this economy is a collection of value functions $\{V_t(s)\}$, decision rules for individual asset holdings $g_t(s)$, for labor supply $n_t(s)$, prices $\{w, r\}$, age dependent, time-invariant measures of agents $\lambda_t(s)$, transfers ξ such that:

- 1) $g_t(s), n_t(s)$ solve the dynamic problem (10)
- 2) The individual and aggregate behaviors are consistent, that is:

$$\tilde{K} = \sum_{t=1}^T \mu_t \int_S g_t(s) d\lambda_t$$

$$N = \sum_{t=1}^T \mu_t \int_S n_t(s) e(z, t) d\lambda_t^w$$

- 3) $\{w, r\}$ are such that they satisfy the optimum conditions, (eq. 4) and (eq. 5);
- 4) The final good market clears:

$$\sum_{t=1}^T \mu_t \int_S \{\varrho_t(s) + [(1 + g_A)g_t(s) - (1 - \delta)g_{t-1}(s)]\} = B\tilde{K}^\alpha N^{1-\alpha}$$

- 5) Given the decision rule $g_t(s)$, $\lambda_t(\omega)$ satisfies the following law of motion:

$$\lambda_{t+1}(\omega) = \int_S Q_t(s, \omega) d\lambda_t \quad \forall \omega \subset \Omega(S)$$

- 6) The distribution of accidental bequests is given by:

$$\xi = \sum_{t=1}^T \mu_t \int_S (1 - \psi_{t+1}) g_t(s) d\lambda_t$$

- 7) The set of taxes $\{\tau_c, \tau_w, \tau_k, \tau_i\}$ is given by (7).

3. DATA AND CALIBRATION

The population age profile $\{\mu_t\}_{t=1}^T$ depends on the population growth rate g_n , on the survival probabilities ψ_t and on the maximum age T that an agent can live. In this economy, a period corresponds to 1 year and an agent can live at the most 51 years, so that $T = 51$. Additionally, we assumed that an individual is born with 15 years old, so that the real maximum age is 65 years old.

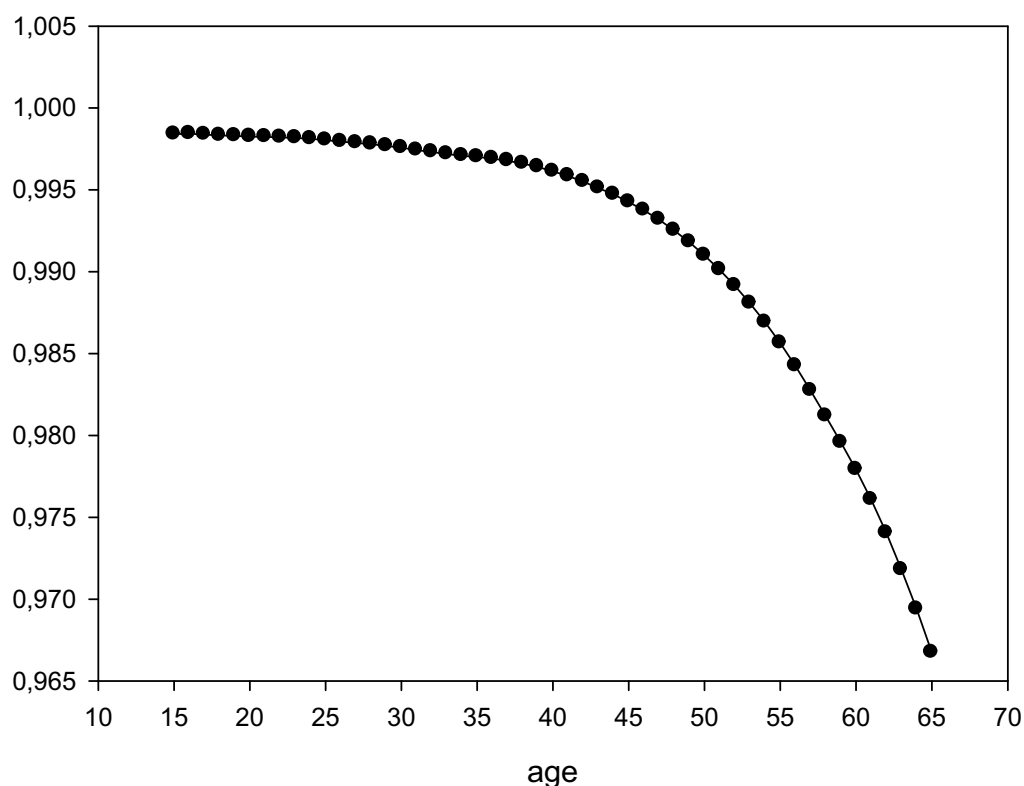
Data on survival probability for each cohort were extracted from IBGE and are shown in Figure 1. The population growth rate is chosen based on the average population growth from 1997 to 2007. This yields a g_n equal to 0.0145.

The values of the parameters related with the individual preferences (β, γ, ρ) are summarized in Table 1. The value of the relative risk aversion parameter γ along with the share of leisure in the utility ρ determines the elasticity of intertemporal substitution of consumption, which is given by $1/[1 - (1 - \rho)(1 - \gamma)]$. Using the values for (γ, ρ) reported in Table 1, we obtain a value of 0.46 for the intertemporal substitution of consumption, which is in the range of the estimates of the microeconomic studies revised by Auerbach e Kotlikoff (1987).

In representative agent models, given the capital income share and the depreciation rate, there is a one to one relationship between the parameter ρ and the fraction of time that individuals spend working in the stationary state. In overlapping generation models, however, such relation is more



Figure 1: Survival probability



complicated because of the heterogeneity among agents. In this case, the procedure that is used to choose ρ is such that the average fraction of time that individuals in our model spend working is consistent with the empirical evidence, which suggests a value near 33%.⁴

The calibration of the parameter σ , which governs the effect of government on the individuals' utility, is more difficult because the empirical literature either do not provide a plausible range of values for it or even a robust evidence of substitutability or complementarity between public and private consumption.⁵ Thus, we decide to carry out simulations in which $\sigma = 0$, $\sigma < 0$ and $\sigma > 0$.

Table 1: Preferences and technological parameters

β	γ	ρ	B	α	δ	g_A	g_n
0.997	4.00	0.62	0.90	0.42	0.041	0.0135	0.0145

In our model, since there is technological progress, the discount factor is given by $\beta = \tilde{\beta}(1 + g_A)^{(1-\rho)(1-\gamma)}$. Given g_A , ρ and γ the parameter $\tilde{\beta}$ is calibrated so that the capital-output ratio in the benchmark economy is equal to 2.75.

⁴See, for instance, Juster e Stafford (1991).

⁵See, for example, Aschauer (1985), Bean (1986), Ahmed (1986), Campbell e Mankiw (1990) and Ni (1995).

The values of technological parameters (B, α, δ) are also summarized in Table 1. We chose a value for α based on the Brazil time series data from the Brazilian Institute for Geography and Statistics (IBGE).

The depreciation rate is given by:

$$\delta = \frac{I/Y}{K/Y} - g_A - n - ng_A$$

We set the investment-product ratio I/Y equal to 0.1916 and the capital-product ratio K/Y equal to 2.75. The productivity growth rate g_A is constant and consistent with the average growth rate of GDP per capita over the second half of the last century. Based on the data from IBGE, we set g_A equal to 1.35%. Thus, the above equation yields a δ consistent with the value shown in Table 1.

Rios-Rull (1996) normalizes the value of parameter B , which measures the total factor productivity, to 1. In this paper, we follow Huggett (1996) so that we chose B to normalize the wage rate w in the benchmark economy. Thus, given a capital-product ratio of 2.75 and $\alpha = 0.42$, the value of B is such that $w = 1$, that is, 0.9.

3.1. Individual productivity

Each agent in this economy is endowed with an individual productivity level $e(z_t, t) = \exp(z_t + \bar{y}_t)$, where \bar{y}_t denotes a permanent component without risk and z_t denotes a temporary component, which follows an auto-regressive process of first order with parameters $(\pi, \sigma_\varepsilon^2)$. Several authors have estimated similar stochastic processes for the labor productivity.⁶ Controlling for the presence of measurement errors and/or effects of such observable characteristics as education and age, the literature provides a range of values for π that goes from 0.88 to 0.96 and for σ_ε from 0.12 to 0.25. The procedure used in this paper to calibrate these parameters was to set $\pi = 0.90$ and adjust σ_ε in such a way that the income distribution in the model matches the observed income distribution. As a measure of the income distribution on data, we use the Gini index which was 0.52 for Brazil in 2006. Thus, choosing a value of 0.07 for σ_ε^2 , the model yields a Gini index of 0.46 in the benchmark case.

The values for \bar{y}_t are constructed following Huggett (1996). We used data from Brazil's National Household Sample Survey (PNAD) on median earnings of full-time workers for each cohort. We divided these values by the total median earnings and, then, interpolated to get the individual productivity component by age \bar{y}_t . In Figure 2, we show the age-efficiency profiles that are used in our calculations.

For computational reasons, we have approximated the $AR(1)$ process which describes the idiosyncratic productivity shock z by a finite Markov chain. First, we discretized the state space Z using a grid of 19 points equally spaced in the interval $[-3\sigma_z, 3\sigma_z]$, where σ_z denotes the unconditional standard deviation of z , that is, $\sigma_\varepsilon / \sqrt{(1 - \pi^2)}$. The transition probabilities are computed using the algorithm described in Tauchen (1986). After calculating the matrix of stochastic transition among the states in Z , we calculated the invariant distribution associated with this matrix and, then, took this result to describe the agents' initial distribution in the economy.

3.2. Fiscal policy

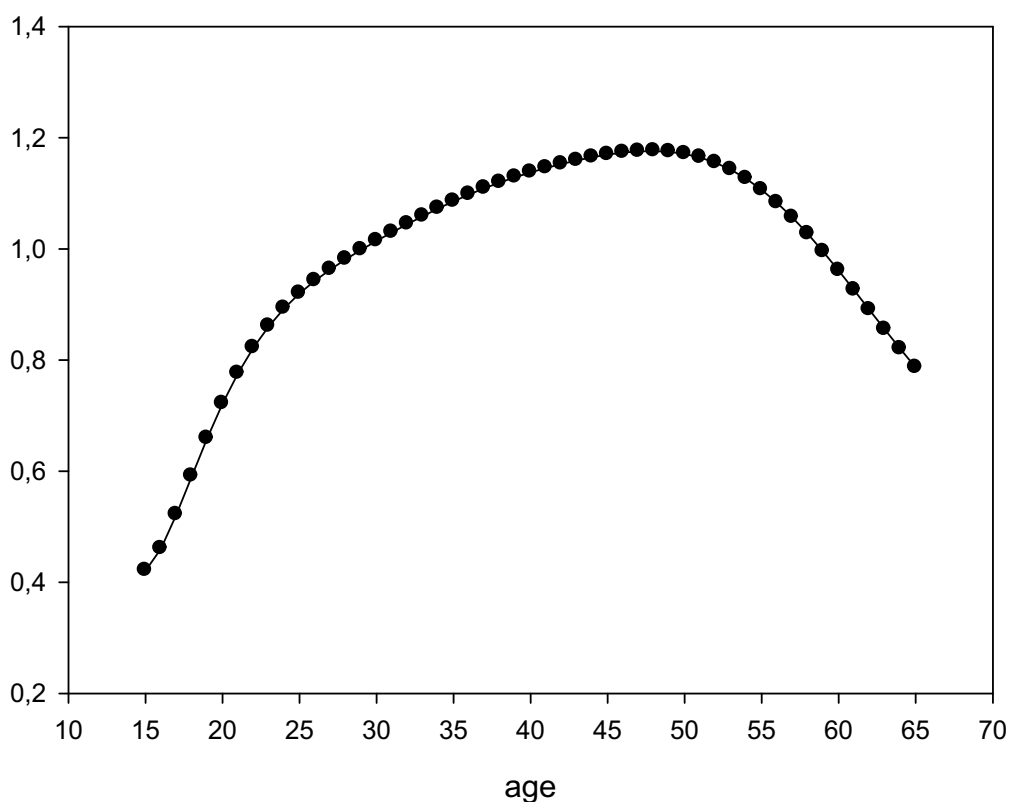
The fiscal policy in our model can be summarized by the set of parameters $\{\theta_c, \theta_w, \theta_k, \theta_i\}$. To calibrate these parameters we use data from the Brazilian Ministry of Finance for 2006, our benchmark year.⁷ Many taxes in Brazil are cumulative in such a way that they end up being levied on both consumption and investment. When this is the case, we multiply the amount collected by the share of consumption and investment on GDP in order to account for the share collected due to taxation on

⁶A revision of this literature can be found on Atkinson (1971) and Floden e Lindé (2001).

⁷For more details about the fiscal parameters see Costa e Pereira (2008).



Figure 2: Age-efficiency profile



consumption and investment, respectively.⁸ In the second column of Table 2, we show the calibrated values for $\{\theta_c, \theta_w, \theta_k, \theta_i\}$ in the benchmark case.

In the third column of Table 2, we show the values for $\{\theta_c, \theta_w, \theta_k, \theta_i\}$ that must prevail after the reform. One can see that, the main goal of the tax reform is to reduce the amount collected from taxes on labor income and savings and increase the amount collected from taxes on consumption. In fact, under the current tax system, about 41% of the total government revenue is due to consumption taxes and 10.15% is due to tax on investment. After the tax reform and given that the government wants to keep the tax burden in terms of GDP unchanged, the former share will increase to 53%, while the latter will decrease to 3.70%.

4. RESULTS

4.1. The welfare cost of taxes

In order to assess the welfare cost of taxes, we calculate the deadweight loss due to an increase of one percentage point in each type of taxation. The deadweight loss of taxation (also called the excess burden) is based on a conceptual experiment where the government imposes (or increases) taxes,

⁸For example, only 26.51% of the amount collected from tax on imported goods is due to consumption. Thus, we multiply the amount collected from tax on imported goods by 0.2651 in order to calculate the share of θ_c due to this type of taxation.

Table 2: Fiscal policy parameters

	Current tax system	After reform
θ_c	0.1365	0.1765
θ_i	0.0337	0.0123
θ_w	0.1008	0.0822
θ_k	0.0611	0.0611
Total tax burden	0.3321	0.3321

thereby distorting prices, and returns the revenue to the taxpayer in a lump-sum basis. Thus, in order to assess the welfare cost of taxation, we measure how much money individuals require to be indifferent between an increase in taxation and no change in the tax system. Our calculations are carried out taking into account different values of the parameter σ , which governs the effect of government on household's utility. As a consequence, we can also investigate how the calculation of the welfare cost of taxes may depend on the way that government expenditures affect individuals' marginal utility.

In the first column of Table 3, we show what type of taxation has been changed and in the other three columns we show the deadweight loss calculated for different values of σ . As one can see in the Table 3, tax on consumption is the least distortionary taxation no matter what value σ takes, whereas tax on investment is the largest one. In fact, our simulations suggest that the welfare cost due to an increase in tax on investment can be more than twice as larger as that due to labor income and 4.5 times higher than that due to tax on consumption. Thus, this result supports a tax reform which replaces taxation on saving with taxation on consumption. However, this argument is based on efficiency issues and the findings presented in Table 3 cannot tell us anything about the distributional implications of such reform. In the next subsection, we provide an assessment of this subject.

Table 3: Deadweight loss with uncertainty

	$\sigma = -0.05$	$\sigma = 0.00$	$\sigma = 0.05$
$\Delta\tau_c$	0.4514	0.3880	0.3306
$\Delta\tau_i$	2.1150	1.8827	1.7364
$\Delta\tau_w$	0.8432	0.7755	0.7171
$\Delta\tau_k$	0.7752	0.7141	0.6587

Moreover, note that the welfare cost of each taxation is higher when we set $\sigma < 0$ and lower for $\sigma > 0$ than its benchmark value $\sigma = 0$. To understand this result, remember that for $\sigma = -0.05$, private and public goods are substituted. Hence, as an increase in taxation lowers the output and thereby the government expenditure, the private consumption tends to increase. As a consequence, individuals require a higher compensation in order to agree with the change in the tax system.⁹

In Table 4, we show the results for the experiment carried out in Table 3, but leaving aside the uncertainty regarding to labor income. In this case, as one can see in the table, the deadweight loss is lower for all taxations, although the difference is more significant for taxes on savings. This is so because in the uncertain environment, individuals build up precautionary savings to protect themselves against low incomes and thereby low consumption levels in future periods. Thus, asset holdings are used to

⁹A similar argument can be used to explain the result for $\sigma > 0$.



smooth out idiosyncratic shocks and, as a result, asset accumulation is less responsive to changes in the rate of return. This prudent behavior entails that the elasticity of savings is lower under uncertainty, so that the distortion caused by taxation tends to be higher. We omit the results for others values of σ because they have the same way as in Table 3.

Table 4: Deadweight loss without uncertainty ($\sigma = 0.00$)

$\Delta\tau_c$	0.3306
$\Delta\tau_i$	1.7364
$\Delta\tau_w$	0.7171
$\Delta\tau_k$	0.6587

4.2. Macroeconomic and distributional impacts

The analysis carried out in the last subsection suggests that, by replacing tax on investment and labor with tax on consumption, the tax reform will reduce the distortion caused by the tax system and thereby put forward capital accumulation and the increase of income. In order to asses this, we show in Table 5 the results of simulation of the tax reform using the calibrated model.

As one can see in Table 5, the macroeconomic impacts of such reform are quite positive. In fact, when $\sigma = 0$ the capital stock and labor increase by 23.43% and 2.10%, respectively, whereas the output increases by 11.05%. These values entail an increase in investment-output ratio and government revenue by 12.38% and 10.98%, respectively.

As shown in the last three columns of Table 5, when $\sigma = -0.05$ the impacts of the tax reform is even higher, with the capital stock, hours worked and income growing to 24.17%, 2,40% and 11.68%, respectively. This is so because, when $\sigma = -0.05$, the distortion caused by the tax system tends to be higher as argued in the last subsection. Thus, the gains due to the tax reform tend to be higher too.

This increase in the long-run income is higher than that found by other papers. For example, Kotlikoff (1992), using a life-cycle model without uncertainty, estimates an increase in output by 8%, while the econometric study carried out by Slemrod (1999) provides values that range from 4% to 6%. This significant impact on the capital accumulation, income and government revenue is the main reason for which this tax reform has been proposed.

In Table 5 we also show the taxes before and after the reform. Note that for the benchmark case, $\sigma = 0$, the model estimates a decrease in the tax on investment and labor income by 67.75% and 18.30%, respectively. As government increases the share of its revenue due to consumption taxation in order to keep the tax burden in terms of GDP unchanged, the tax on consumption is expected to increase by 33.21%. Along with the increase of average income of economy, the large fall in tax on investment and labor income more than offset this increase in tax on consumption, so that the tax reform tends to increase the consumption and thereby the individuals' welfare.

Nevertheless, this is not the case for a significant number of agents in the economy. This is so because in our model individuals face idiosyncratic shocks and, as borrowing constraints prevent them from insuring themselves against those shocks, some agents who faced a bad sequence of shocks will save a small amount of their disposable income or will not save at all. Therefore, these agents will not take advantage of the fall in tax on investment directly and thereby the high increase in tax on consumption may prevent their consumption from increasing or, at least, from growing at the same pace as the consumption of the average individual. As a matter of fact, the consumption of the poorest 20% of individuals rises by 1.9%, while the average consumption goes up by 7.5%. The situation is even

Table 5: Simulation results of the tax reform

	$\sigma = 0.0$		$\sigma = -0.05$	
	Benchmark	After reform	Benchmark	After reform
Capital stock	2.0538	2.5350	2.0705	2.5710
Hours worked	0.3087	0.3152	0.3202	0.3279
Output	0.7454	0.8273	0.7601	0.8489
Investment/Output	0.1916	0.2154	0.1901	0.2140
Consumption/Output	0.8084	0.7846	0.8099	0.7960
Government revenue	0.2475	0.2747	0.2524	0.2819
τ_c	0.1668	0.2222	0.1663	0.2205
τ_i	0.1749	0.0564	0.1772	0.0579
τ_w	0.1748	0.1428	0.1748	0.1418
τ_k	0.1442	0.1442	0.1442	0.1442

worse when we compare with the increase observed for the richest 20% of the population, 18.23%. As a consequence, the standard deviation of consumption increases from 0.2473 to 0.2834.

Needless to say, the welfare of the poorer individuals falls significantly in regard to the welfare of the richer ones, increasing the welfare inequality. In fact, before reform, the welfare of the richest 20% of individuals in regard to the poorest 20% ones is 0.22 and after the reform that ratio increases to 0.288.

In Table 6, we show the share of individuals who worsen after the tax reform, controlling for their income. This assessment is done by comparing the individual value function $V_t(s)$ in each state s before the reform with that observed after the change in the tax system. As one can see in the Table 6, nearly 90% of the individuals whose income is lower than 20% of the average income would not vote for the tax reform. This proportion decreases as we raise the income of the individuals in the sample. Indeed, 63.55 % of agents whose income is lower than 40% of the average worsen as the tax system change. If we take into account all individuals in economy, 37.45% would prefer the economy before reform. Needless to say that the reform does not bring about a Pareto improvement since it is unable to improve the welfare of all individuals.

Table 6: Share of individuals who worsen with the reform (%)

$< 0.20y_m$	$< 0.40y_m$	$< 0.60y_m$	$< 0.80y_m$	All economy
89.59	63.55	51.67	40.84	37.45

The problem with the change in the tax system carried out in this paper lies in the fact that it has a twofold effect on individuals' budget constraint: one positive due to the reduction of taxes on investment and labor, and another negative due to the increase in tax on consumption. Thus, for those who save the most part of their disposable income, the former effect tends to more than offset the latter, while the opposite tends to be true for those who spend almost all their disposable income on consumption.

These findings entail that the market incompleteness is crucial to determine the distributional impacts of a tax reform that replaces taxes on savings and labor income with consumption taxation. As



a matter of fact, the results above diminish the attractiveness of a consumption-based tax system, at the same time that it strengthens the arguments in favor of saving and labor income taxation. This is so because taxation on income and savings levies a higher tax on savers and, as a consequence, could redistribute welfare from the better off (not credit constrained) to the worse off (credit constrained).

Furthermore, it should be stressed that the trade-off between economic growth and inequality associated with the tax reform analyzed in this paper tends to be more important in poor countries or emerging economies in which the share of low income individuals, those who are likely to worsen with the reform, is high. Our results suggest that a tax reform toward a consumption-based tax system should be carried out after the country had reached a certain stage of economic development in which there is more equality, and not the opposite. As a matter of fact, governments from developed countries usually have a higher share of their revenue based on consumption taxation than poor countries and emerging economies have.

However, the negative impacts on welfare inequality presented above can be diminished by adopting some mechanisms which avoid the increase of taxation on consumption for low income individuals. As an example, we carried out simulations in which taxation on consumption is kept at its benchmark level for the poorest 20% of individuals. In this case, although the capital accumulation and output grow by 10.01% and 21.05% (less than the previous cases), the share of individuals who worsen after the change in the tax system drops to 28.8%. Thus, even though it is possible to avoid some increase in welfare inequality, it cannot be done without undermining the growth of output since it usually entails some kind of compensation to low income individuals to the detriment of richer ones.

4.3. The social welfare criterion

When one has to compare inequality or welfare of distributions across agents, there is still some disagreement about the method to be used. In this subsection, we take a stand on two specific social welfare functions in order to assess the welfare implications of the tax reform further. We start with a welfare criterion based on an utilitarian social welfare function among all generations currently alive in the steady state. Under this criterion, well-being of the heterogeneous population is aggregated by the weighted sum of individual utilities. In particular, given the decision rules $g_t(s)$ and $n_t(s)$ and the invariant cross-sectional distribution $\lambda_t(s)$ of the generation t across the states s , the average steady-state utility for a taxation policy arrangement $\Omega = \{\theta_c, \theta_w, \theta_i, \theta_k\}$ can be written as:

$$SWF_1(\Omega) = \sum_{t=1}^T \mu_t \beta^{t-1} \psi_t \int_S u(c_t(g_t(s), n_t(s)), 1 - n_t(s)) d\lambda_t(s) \tag{11}$$

Here, the average utility for each generation t , $\int_S u(c_t(g_t(s), n_t(s)), 1 - n_t(s)) d\lambda_t(s)$, is weighted by the unconditional probability of being alive at age t , $\psi_t = \prod_{k=1}^t \psi_k$, by the intertemporal discount factor, β , and by the share of individuals aged t in the population, μ_t .

Alternatively, one could argue that a better way to evaluate the distributional implications of the tax reform would be to consider a person who had to choose a particular distribution in a complete ignorance of what his own relative position would be within the system over her lifetime. In this case, the social welfare should be measured by the ex-ante expected (with respect to labor income shocks) lifetime utility of a newborn in a stationary equilibrium. Thus, given that all newborns start with zero assets, the social welfare function implied by the policy arrangement $\Omega = \{\theta_c, \theta_w, \theta_i, \theta_k\}$ is the expected value of the value function in regard to shock level at birth, that is:

$$SWF_2(\Omega) = E_z V_1(0, z) \tag{12}$$

where $V_1(0, z)$ is the solution of the dynamic program in (10).¹⁰

Table 7 shows the values of $SWF_1(\Omega)$ and $SWF_2(\Omega)$ for the benchmark and after-reform cases. It can be seen that the social welfare falls nearly 4.76% with the reform when we use $SWF_1(\Omega)$, whereas it increases by 5.20% based on $SWF_2(\Omega)$. Intuitively, the first result is associated with the curvature of the social welfare function, which in our context is determined by the curvature of the individuals utility function. The concavity of the social welfare function reflects the marginal social value of equality – the extent to which a dollar is deemed to be worth more to a poorer individual than to a richer one.¹¹ A high curvature of $SWF_1(\Omega)$ means a high aversion to inequality and, thereby changes in consumption for low income agents have a larger impact on social welfare than for high income individuals. Thus, a tax reform that makes poor agents worse off is more likely to decrease $SWF_1(\Omega)$ since it is given by the weighted sum of individuals' utility.

Table 7: Social welfare implications of the tax reform

	$SWF_1(\Omega)$	$SWF_2(\Omega)$
Benchmark	-94.77	-114.37
Reform	-99.28	-108.42

On the other hand, if we ask a newborn under what tax arrangement she would like to live, Table 7 shows that she would prefer the steady state after reform. In order to understand this result, one should initially consider that at the beginning of the first period, individuals draw a realization of z from a normal probability distribution with mean zero and variance σ_z^2 and, as a consequence, they face a relatively large probability to start with a labor productivity not far away from the average labor productivity. Considering that individuals in this situation or better improve with the tax reform, we have that the social welfare measured by SWF_2 increases. In other words, since labor income trajectories in which a newborn will be better off after the reform are more likely to be realized, she prefers the steady state implied by the new tax system.¹²

4.4. The relevance of accidental bequest transfers

So far we have assumed that accidental bequests are transferred in a lump-sum fashion to all agents in the economy. These transfers are small, amounting about 1.5% of the average income under the baseline calibration and, as a consequence, it should not largely affect the reported results. The relatively small size of the accidental inheritances is due to the fact that individuals in our model live up to age 65. Given that the conditional survival probability falls faster for the elderly, those transfers would play a more important role in a model with a longer lifespan. The potential importance of the lump-sum transfers in an economy with market incompleteness and borrowing constraints relies on the fact that it provides individuals a partial insurance against labor income shocks. In this subsection, we briefly assess an alternative approach to the uniform distribution of bequests.

The literature has attacked this problem of accidental bequests in a variety of ways. For example, Ríos-Rull (1996) eliminates accidental inheritances by imposing the existence of a market for one-period annuities, where agents can perfectly insure themselves against lifetime uncertainty. In Imrohoroglu

¹⁰We used a quadrature numerical integration method to compute the expectancy in (12).

¹¹See, for example, Atkinson (1970, 1973) and Atkinson (1980).

¹²Nevertheless, it should be stressed that our model abstracts from any kind of link across the generations. In particular, if the productivity shocks of the newly born agent was correlated with her parent's productivity, we would have to use the appropriate conditional distribution in the calculation of (12). In this case, it is not clear beforehand if SWF_2 would increase.



et alii (1998), agents receive accidental bequests only once, at a pre-determined age.¹³ In particular, their experiments consist in first giving all bequests to the agents at age 45, which they consider a plausible age to receive inheritances and, second, giving all bequests to the newborns. They find that the aggregate capital decreases in the first case due to the fall in savings on the young agents, while it increases under the second scenario because of the monotonicity of the policy function for assets. A similar experiment is carried out in Hubbard e Judd (1987), who find that the results are slightly sensitive to changes in the timing of the receipt of the accidental inheritances.

Here we propose an alternative approach, which consists in simply eliminating the accidental bequest of the system altogether. In particular, we assume that the government neither transfers the collected amount of bequests to individuals nor uses it to finance its current expenditures. In Table 8, we show the results for selected statistics when the transfers are left aside. In order to make the comparison easier, we also show in Table 8 the results that include the accidental inheritances.¹⁴ As one can see in the table, the absence of the lump-sum transfers increases hours worked and asset holdings, thereby enhancing the output of economy in both benchmark and after-reform steady states. This is so because agents vary their labor supply and savings in order to (partially) keep the previous life cycle levels of consumption and utility. Overall, however, it has limited impact on the results reported previously, which should be expected given the small magnitude of those transfers.

Table 8: Descriptive statistics with and without accidental inheritances

	With transfers		Without transfers	
	Benchmark	Reform	Benchmark	Reform
Capital stock	2.0538	2.5350	2.0599	2.5448
Hours worked	0.3087	0.3152	0.3116	0.3182
Output	0.7454	0.8273	0.7542	0.8351
τ_c	0.1668	0.2222	0.1699	0.2268
τ_i	0.1749	0.0564	0.1762	0.0561
τ_w	0.1748	0.1428	0.1748	0.1424
τ_k	0.1442	0.1442	0.1442	0.1442

5. REMARKS

This paper develops and calibrates a dynamic general equilibrium model with uncertainty to assess the macroeconomic and distributional implications of a tax reform, which replaces tax on investment and labor income with tax on consumption. We use data from the Brazilian's economy to carry out our analysis of the effects of such reform since it has been proposed in Brazil as a way of accelerating the economic growth thereby increasing the long-run income. We also use our model to calculate the deadweight loss of each type of taxation and compare the results with the case in which the uncertainty is left aside.

Our results suggest that tax on savings is the most inefficiency taxation, while the tax on consumption is the least one. Thus, the reduction of the former and the increase of the latter, in order to keep the tax burden in terms of GDP unchanged, reduce the inefficiency of the tax system and thereby increase

¹³In their model, agents may live up to age 85 and the accidental bequest transfers amounts to nearly 4.5% of the average income.

¹⁴All results in Table 8 are calculated with a $\sigma = 0$.

capital accumulation and the output of economy. The expansion of the output estimated in this paper is higher than that estimated in some econometric studies such as Slonred (1999) among others.

Nevertheless, the results that come from the analysis carried out in this paper about the impacts of the tax reform on the welfare distribution cast doubt on the capability of such reforms in improving the economic environment. This is because that reform raises welfare inequality in the cross-section. As a matter of fact, the consumption of the richest 20% of individuals increases in relation to that of the poorest 20% and the ratio of welfare between the former and the latter goes up by nearly 23%. As a consequence, nearly 37% of individuals would prefer the economy before reform.

Therefore, even though the tax reform proposed by the Brazilian's government reduces the distortions associated with the high income and capital tax rates that are paid by households mainly in the top income brackets, it also reduces the redistributive properties of the current tax system and, as a consequence, this policy switch implies a trade-off between efficiency and equality.

Another interesting result that comes from our assessment is that the uncertainty in the economic environment may be important to the calculation of the welfare cost of taxes, mainly for taxation on savings. In fact, as individuals increase their savings in an uncertain environment in order to build up precautionary savings to protect themselves against future negative income shocks, asset accumulation is less responsive to changes in the rate of return. As a consequence, the elasticity of savings is lower under uncertainty and the distortion caused by taxation tends to be higher as well.

There are some dimensions in which the theory of wealth differences used in this paper can be enriched, which is a goal of ongoing research. First, we want to investigate the consequences of allowing the households in our model economy to engage in activities such as human capital accumulation that change the characteristics of stochastic process that underlay the income paths of individuals. Second, in line with Castaneda et alii (1999), we also aim to study the implications of altruism, which provides a reason for households to accumulate significantly larger amounts of wealth than those that are needed to maintain a high standard of living during the life-cycle. This feature, along with the existence of lifespan uncertainty, introduces another dimension of heterogeneity that can be helpful to better assess the impacts of the tax reform on wealth distribution.

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A. APPENDIX

Table A1 presents a summary description of the Brazilian tax system. The first column shows the name of each tax or contribution, column 2 presents the amount collected in terms of GDP. Finally, column 3 shows the tax jurisdiction and column 4 contains the incidence of each type of taxation.

The government tax reform proposes to eliminate the COFINS, PIS and CIDE and creation of federal value-added tax, IVA-F. The COFINS, PIS and CIDE are cumulative taxes, with incidence on both consumption and investment. By definition, the IVA-F has incidence only on consumption.

Additionally, the proposal intends to create a new ICMS. As one can see in Table 7, the ICMS is responsible for 7.10% of the total tax burden. The tax rate of the ICMS is 7% in some states and 12% in others. The government wants to replace these rates with a single 2% new one. We find the value of new ICMS multiplying the old value by $2/9.5$, where 9.5 is the mean between 7% and 12%.

The tax reform also intends to eliminate the education wage – a contribution made by employers. The amount collected with this contribution will be added to IVA-F. Moreover, the employer contribution to the Social Security system will decrease from 20% to 14%. To capture this change, we multiply the total amount collected with the Social Security by $14/20$.

Table A1 – Description of Brazilian's tax system in 2006

Taxes and contributions	Tax burden	Jurisdiction	Incidence
Labor's income – IRPF	0.0037	Federal	Labour
Firms' profits – IRPJ	0.0240	Federal	Capital
Gains with labor – IRRF-T	0.0168	Federal	Labour
Gains with capital – IRRF-C	0.0091	Federal	Capital
Gains to foreign – IRRF-E	0.0032	Federal	Capital
Others gains – IRRF-O	0.0020	Federal	Capital
Financial operations – IOF	0.0029	Federal	Cons/Invest
VAT on Manufac. products – IPI	0.0115	Federal	Cons/Invest
Import and export taxes – (II and IE)	0.0042	Federal	Cons/Invest
Bank account deposits – CPMF	0.0138	Federal	Cons/Invest
Social contribution – COFINS/PIS/PASEP	0.0499	Federal	Cons/Invest
Fuels – CIDE	0.0034	Federal	Cons/Invest
Firms' net profits – CSLL	0.0120	Federal	Capital
Others – Others revenue	0.0019	Federal	Capital
Contri. to agriculture – FUNDAP	0.0001	Federal	Consumption
VAT on goods & services – ICMS	0.0710	State	Cons/Invest
Vehicle license registration – IPVA	0.0052	State	Capital
Property transmissions – ITCD and ITBI	0.0013	State/Local	Capital
Sales tax on service – ISS	0.0062	Local	Cons/Invest
Urban (IPTU) and Rural property	0.0042	Loc/Fed	Capital
Payroll – Contrib. Employer/Employee*	0.0784	Fed/Sta/Loc	Labour
Fees	0.0053	Fed/Sta/Loc	Consumption
Total tax burden	0.3321		

Source: Ministry of Finance, * FGTS, INSS, Transfer to Others, S-System, Social Contribution.