



WP/05/142

# IMF Working Paper

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## Tax Systems under Fiscal Adjustment: A Dynamic CGE Analysis of the Brazilian Tax Reform

*Victor Duarte Lledo*

**IMF Working Paper**

Finance Department

**Tax Systems under Fiscal Adjustment:  
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Prepared by Victor Duarte Lledo<sup>1</sup>

Authorized for distribution by Ydahlia Metzgen

July 2005

**Abstract**

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This paper uses a dynamic computable general equilibrium model (CGE) to analyze the macroeconomic and redistributive effects of replacing turnover and financial transaction taxes in Brazil by a consumption tax. In order to approximate Brazil's compliance with its fiscal adjustment targets, the proposed reform is subject to a non increasing path for the level of public debt. Despite an increase in the average consumption tax rate in the first years after the reform, a majority of individuals experienced an increase in their lifetime welfare. This result rejects the hypothesis that the on-going fiscal adjustment effort carried on by the Brazilian government was an obstacle to the implementation of a more efficient tax system.

JEL Classification Numbers: C68, E60, H20, H77

Keywords: Tax reform, Fiscal adjustment, Computable general equilibrium, Brazil.

Author(s) E-Mail Address: vlledo@imf.org

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<sup>1</sup> I am grateful to Ydahlia Metzgen, Dmitry Gershenson, Ricardo Varsano, Ana Corbacho, and the Brazilian ED's office for valuable comments. I am also indebted to Rody Manuelli, Ian Coxhead, Charles Franklin, Steven Deller and Sergio Ferreira for numerous inputs in an earlier draft of this paper published as part of my PhD Dissertation at the University of Wisconsin-Madison.

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## I. INTRODUCTION

The need to reduce macroeconomic instability through fiscal adjustment has been one of the main forces shaping tax systems in developing countries over the last two decades (Tanzi, 2003; Perry et al 2000). In Latin America, tax reform experiences during the eighties and early nineties have helped to raise tax revenue-GDP ratios through efficiency-enhancing changes in the tax structure, such as the replacement of taxes on international trade by a value-added tax (VAT). The late 1990s, however, saw a drift in tax policy away from efficiency-enhancing tax reforms (Shome, 1999). Further intensification in tax effort in some Latin American countries was accompanied by the implementation of unconventional and inefficient taxes such as those on financial transactions (Coelho et al, 2001). Once in place, the revenue-raising gains accompanying such taxes have usually prevented any reforms proposing their replacement by less distortionary tax bases in countries undergoing a process of fiscal adjustment.

Brazil provides a clear-cut illustration of this problem. Tax policy since the mid-1990s has been marked by an increasing reliance on indirect taxes on corporate revenues (business turnover) and financial transactions. A technical consensus over the distortionary effects of such taxes emerged during the same period leading to a series of tax reform attempts.<sup>2</sup> Nonetheless, several attempts to replace these distortionary taxes by more efficient taxes during the last decade have failed. The continuous fiscal adjustment process formalized in 1998 with the establishment of explicit targets for the primary fiscal surplus of the government has been pointed to as one of the main reasons for the tax reform deadlock (Araujo, 2001; Varsano, 2000; Werneck, 2003). The tax revenue level compatible with fiscal adjustment targets could not be generated through alternative (and less distortionary) tax bases without imposing welfare losses to particular sectors and individuals to an extent that would render the reform politically unfeasible.

The objective of this paper is to test this hypothesis using a dynamic computable general equilibrium (CGE) approach. The analysis will rely on Auerbach and Kotlikoff (1987) overlapping generation model – hereafter referred as the A-K model. This model will be calibrated to resemble economic conditions during President Cardoso's two consecutive presidential mandates (1995/2002), a period of intense legislative activity and gridlock involving several tax reform proposals. The macroeconomic and distributive effects of replacing federal taxes on corporate revenues (COFINS, PIS-PASEP) and financial transaction (CPMF, IOF) in the Brazilian tax system by a broad-based, uniform federal VAT will then be simulated under a fiscal adjustment restriction.

The fiscal adjustment restriction is incorporated into the model by setting the nominal level of the consolidated net public sector debt constant and equal to its steady-state level throughout the transition. An equilibrium path for the average consumption tax rate is

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<sup>2</sup> Such taxes are widely believed to distort investment and trade and reduce economic growth in the long run due to their cascading nature (Due, 1988 ; Zee, 1995).

determined under this fiscal adjustment restriction and its growth impacts in the medium and long-run computed. Using the concept of remainder of lifetime utility also developed in the A-K model, the paper quantifies the intergenerational incidence of the resulting tax system with the objective of providing a preliminary analysis of the political feasibility of the proposed reform.

In limiting the tax reform only to the federal sphere, the intention was to isolate the restrictions imposed by fiscal adjustment on tax reform from those of a fiscal federalist nature. The fiscal federalist restriction, i.e., how distortionary taxes could be eliminated without compromising the level and intergovernmental distribution of tax revenues, has been posed as another important obstacle to the implementation of the Brazilian tax reform (see Werneck 2003). Thus, replacing COFINS, PIS-PASEP, CPMF and IOF, all federal taxes by a federal VAT avoids any direct changes in the amount of tax revenues available to each government level and leaves the fiscal federalist restriction non binding.<sup>3</sup>

Our results have provided some initial evidence that fiscal adjustment could not have been seen as an obstacle to the implementation of more efficient tax systems. The proposed tax reform has not implied any short-run decrease in income, the supply of labor or the stock of capital. Neither did it increase interest rates nor depress wages. Moreover, the proposed tax reform generated positive welfare gains to 70 percent of living cohorts, which should facilitate, in principle, its implementation in more inclusive voting mechanisms.

The results above stem from the fact that the proposed reform can be interpreted as a partial switch to a consumption tax system from an income based one. Taxes on corporate revenues and financial transactions are shown to be equivalent to a tax on general income defined as a tax levied on both capital and labor income whose separate incidence among both factors cannot be identified (see Appendix I). The CGE literature has yielded mixed results with respect to partial or complete reversions to consumption based tax systems.<sup>4</sup> Our paper contributes to the dynamic CGE literature by showing that the positive macroeconomic effects and widespread welfare benefits of a partial reversion to a consumption based system

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<sup>3</sup> Changes in the federal tax structure could still affect the allocation of tax revenues among government levels indirectly through general equilibrium effects on subnational tax bases and strategic interactions between federal and subnational officials in the revenue-raising process of the new federal tax system. While the existence of such effects should be acknowledged, they are not as easily identified as those of a more direct nature.

<sup>4</sup> Simulation results using overlapping generation models (Auerbach, Kotlikoff and Skinner, 1983; Auerbach and Kotlikoff, 1987) and in infinitely lived representative agent models (Lucas, 1990; King and Rebelo, 1990; Jones, Manuelli and Rossi, 1993, Stokey and Rebelo, 1995) confirmed the growth and welfare benefits of dropping income taxes for the U.S. tax system. On the other hand, Milesi-Ferretti and Roubini (1994) came to the result that eliminating income taxes presented no growth effects while Krussel, Quadrini and Rios-Rull (1996) concluded that switching to a consumption tax system induces a lower output than income taxes and does not change the welfare of the median voter.

could be achieved even when the government cannot rely on debt to shift away part of the additional burden on older generations usual under such tax systems.<sup>5</sup>

Previous dynamic CGE analysis of the Brazilian tax reform have been conducted by Araujo and Ferreira (1999). However, their tax reform experiments were simulated under the standard revenue neutrality. Moreover, Araujo and Ferreira carried no assessment based on the distributive impacts of the reform given the representative agent nature of their model. This paper extends Araujo and Ferreira's by introducing heterogeneity and augmenting the revenue neutrality assumption to incorporate additional tax revenues necessary to service Brazil's public debt.

The remainder of this paper is organized as follows. The next section provides a brief background on the deterioration of the Brazilian tax system and the attempts to reform it during the Cardoso administration. The analysis is centered on the role played by fiscal adjustment in this process. The A-K model used to simulate the proposed tax reform is presented in Section III. Section IV briefly describes the model parameterization and calibration procedures. Section V reports the macroeconomic and welfare impacts of the main tax reform proposal. Section VI discusses the main conclusions and proposes an agenda for future work. Two appendices provide additional support for the analysis in the main text. The equivalence between taxes on corporate revenues and a tax on general income is presented in the Appendix I. Appendix II documents the details in the model parameterization and calibration.

## **II. FISCAL ADJUSTMENT AND THE BRAZILIAN TAX SYSTEM.**

The macroeconomic stability that followed the successful implementation of the Real Plan in 1994 was a mixed blessing for Brazilian public finances. The fall in inflation led to an increase in real income by low-income groups and the resumption of foreign direct investment (FDI) attracted by more stable macroeconomic conditions. The same low inflationary regime, however, was responsible for the loss of important quasi-fiscal sources of revenue such as seignorage and a rise in various types of financial public spending.<sup>6</sup> Thus, adjusting government budgets by cutting non-financial expenditures or increasing tax revenues in order to sustain a level of public debt compatible with a low-inflationary regime became a necessary condition for the sustainability of Brazil's macroeconomic stabilization.

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<sup>5</sup> Jones, Manuelli and Rossi (1993,1997) and Bull (1993) showed that if the government has no restrictions in the amount of resources that it can borrow or lend, in the long run, all distortionary taxes on human capital, physical capital and even consumption must be zero.

<sup>6</sup> Financial public spending is defined as the resources used to restructure the financial sector and funds used to service the public debt.

This task was pursued through strong enforcement of short run fiscal surpluses for the consolidated public sector.<sup>7</sup>

As a result of budget rigidities, the fiscal adjustment effort was mostly centered on the revenue side. Adjusting the spending side proved itself a very difficult task given the substantial increase in social security entitlements that federal and sub national governments were left to honor with the 1988 Constitution. The result was a substantial increase in the total tax burden. The total burden of the Brazilian tax system fluctuated around 25 percent during most of the period between 1968-94 ( top line in Figure 1). The increasing trend observed in 1993 was sustained and accelerated after 1999, with the total tax burden exceeding 35 percent in 2002.<sup>8</sup>

The observed increase in the tax burden was not uniform across different tax bases. The most noticeable changes were the increasing reliance of the federal government on indirect forms of taxation based on corporate revenues (turnover) and financial transactions taxes and a departure from its value-added tax base. The growing participation of turnover and financial transactions in total revenue collection was particularly evident after 1999 when they start to account for more than 17 percent of total tax revenue second only to the historically dominant broad-based state VAT (ICMS).<sup>9</sup>

The shift in the Brazilian indirect tax system towards corporate revenues and financial transactions did not pass unnoticed and several attempts were undertaken to curb it during the 1990s.<sup>10</sup> Proposals to eliminate taxes on corporate revenues were originally proposed in the 1988 Constitutional reform as well as in 1992 when a special committee at the executive branch of the federal government (CERF) was set up to re-evaluate the 1988 Constitutional changes in the tax system. Five tax reform proposals have been submitted to the Brazilian National Congress since 1997. Four of them advocated the elimination of federal taxes on corporate revenues; two defended the elimination of both corporate revenues and financial transaction taxes. None of the proposals were voted on the Congressional floor.

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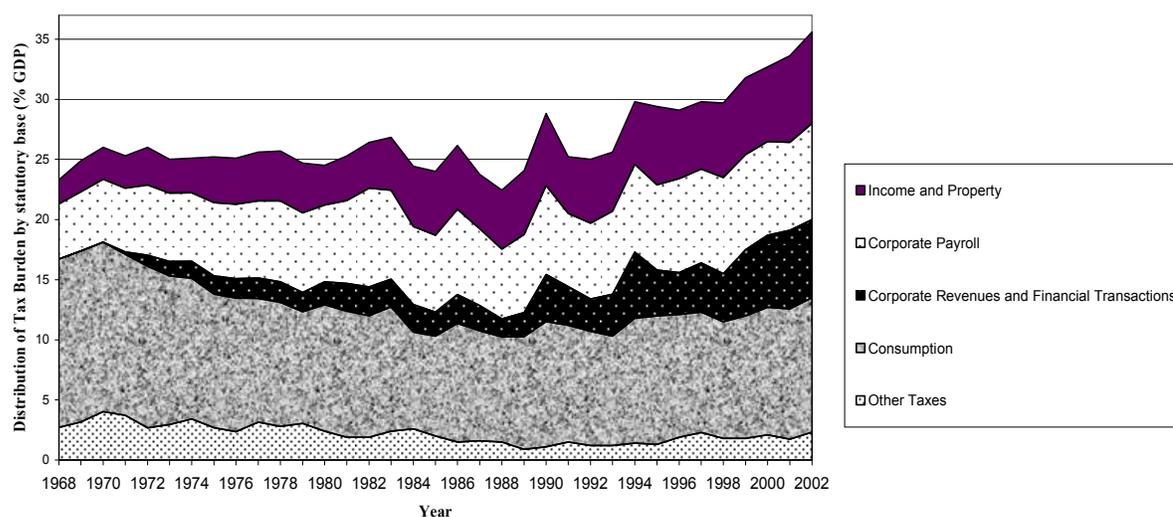
<sup>7</sup> While an initial fiscal adjustment effort can be observed in 1994 and 1995, the process of fiscal adjustment was formally initiated only at the end of 1998 when explicit fiscal targets for the fiscal surplus of the consolidated public sector were included in the program agreed with the IMF. Fiscal surplus target for 1999, 2000 and 2001 were respectively 2.6, 2.8 and 3 percent of GDP.

<sup>8</sup> This new tax burden level was the result of tax rate increases as well as the intensification of revenue collection efforts from all government levels in almost all their respective statutory tax bases. This point is also illustrated in Table A-1 in the Appendix II, which decomposes the average tax burden before and after 1994 by statutory base and jurisdiction assignment. Tax burden in 2003 is estimated to be slightly above the 2002 figure at 35.8 percent (Afonso and Araujo 2004).

<sup>9</sup> This trend has continued . 2004 data from Brazil's Secretary of Revenue show taxes on corporate revenues and financial transactions at 20.5 percent of total tax revenue with ICMS stable around 22 percent.

<sup>10</sup> See Dain (1995), Lemgruber (2000) and Werneck (2003) for a more detailed historical account of the tax reform process during the last decade.

Figure 1. Evolution of the Brazilian Tax Burden and its Composition



Source : Brazilian Economic Development Bank (BNDES), Department of Economics (DEPEC).

The inability to eliminate corporate revenue and financial transactions goes beyond the apparent lack of political initiative of the federal government during President Cardoso's mandate (Werneck 2003).<sup>11</sup> Four out of the six tax reform drafts debated by Brazil's National Congress since 1995 were proposed by the executive branch, out of which two proposed the elimination of all federal taxes on corporate revenues. The reform deadlock cannot be explained by divergences regarding the preferred tax base replacement either given that all major tax reform proposals described above proposed a VAT as the alternative tax base. Instead, the implementation failure has been widely attributed to the inability in matching two important political restrictions constraining the performance of the Brazilian public sector: a fiscal adjustment and a fiscal federalist restriction.

The fiscal adjustment restriction set as priorities in maintenance of the new low inflationary regime : (i) elimination of structural public deficits and (ii) stabilization of public sector debt. These objectives were strongly pursued by the Ministry of Finance and meant that the proposed tax reform could not compromise, even in the short-run, the total amount of revenues required by the consolidated public sector. Defenders of the status quo have justified their preference for corporate revenues and financial transactions based on their high revenue-raising ability and, even more importantly, on the fact that such taxes were not shared with sub national governments<sup>12</sup> Furthermore, it was unclear whether the rate and the

<sup>11</sup> A common argument was that President Cardoso preferred to allocate its political capital in the first years of his first mandate to obtain congressional support for a Constitutional amendment that would allow him to run for re-election. National and local electoral campaigns in the subsequent years played an important role in the continuing procrastination of the tax reform debate.

<sup>12</sup> The simplicity in which their tax bases are defined makes it more difficult for taxpayers in the formal sector to evade and, in the particular case of the CPMF, prevents even tax evasion from activities in the informal

(continued...)

breadth of an alternative less distortionary consumption base was capable of matching the revenues raised under the more distortionary indirect taxes and whether this would be politically acceptable by individuals and firms. Even if they were, it was also not clear if the revenues raised under the new tax system would be appropriated by the federal government thus increasing their chance of being directed towards the goal of fiscal adjustment.

The fiscal federalist restriction, defended by sub national elected officials, constrained tax reform proposals to maintain the current level of tax revenues available to states and municipalities, as well as the tax autonomy those members of the federation acquired after the 1988 tax reform. This restriction had an indirect impact on the elimination of taxes on corporate revenues and financial transactions to the extent that in all proposals the elimination of such taxes was part of a more comprehensive reform of the indirect tax system. Such reform would involve the elimination of the current dual VAT system comprised of a federal and state VAT. The loss in revenues stemming from the elimination of all turnover taxes (COFINS, PIS-PASEP) and federal and state VATs would be recouped for the most part by a new broad-based VAT. The new system would also eliminate state variations in the VAT rate in order to avoid tax competition. A debate on the preferred jurisdiction of the new VAT led to alternative proposals.<sup>13</sup> State governments started opposing any fundamental change in the current dual VAT system given their uncertainty over the impact of the proposed new system on their flow of disposable tax revenues.

With individual points in the Brazilian tax reform being subject to different restrictions, a possible way out of the tax reform gridlock could be to break the reform in two: (i) a reform of the federal tax system and (ii) a reform in the intergovernmental tax system. The former would deal with the elimination of all federal cascading taxes and its replacement by a unified VAT while the later would tackle tax base assignment and revenue-sharing arrangements among federal and subnational governments.<sup>14</sup> Reform of the federal tax system should in principle be easier as it would only be subject to the fiscal adjustment restriction.<sup>15</sup> Federal tax reform should also be dealt with first as it would promote growth and thus soften the fiscal adjustment restriction for the forthcoming round of reforms.

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sector. In addition such taxes have been usually levied under relatively smaller rates and on a much broader base than existing VATs. As a result, their incidence was not perceived to be as concentrated in particular sectors or individuals as VATs facilitating their implementation and subsequent enforcement.

<sup>13</sup> All proposals submitted by the executive branch of the federal government have been in favor of assigning the new VAT base to the federal government. Revenues proceeds would be shared with states according to a new revenue-sharing agreement. On the other hand, the proposal emerging from the National Assembly advocated the continuity of a dual-assignment VAT now under a unified tax base. States would be able to keep the revenues collected by their state administered VAT. New revenue sharing agreements were proposed only for the federally administered portion of the VAT.

<sup>14</sup> The federal tax reform round could also cover the constitutional mandated revenue earmarking of federal taxes to federal expenditure programs.

<sup>15</sup> Both fiscal federalist and fiscal adjustment restrictions should play important roles in the reform of the intergovernmental tax system.

While the tax reform implementation strategy at the end of President Cardoso's second mandate and currently under President's Lula presidential term have gone in this direction, the approach was more gradual and piecemeal than one may originally have desired. The replacement of COFINS and PIS-PASEP by a VAT was separated from proposals advocating changes in the federal and state VAT legislation. Legislation converting the PIS-PASEP and COFINS into a VAT was implemented in 2002 and 2003, respectively. However, there are still some sectors taxed under the old turnover regime. Moreover, the elimination of the IOF and CPMF has faced much more resistance with reform efforts focused on increasing the range of exempted financial transactions. One immediate explanation for the gradual approach has been the inability of a more comprehensive reform in complying with the fiscal adjustment restriction.

The analysis in this paper represents an initial attempt to explore this hypothesis by analyzing the effects of replacing on a once and for all basis all the cascading taxes assigned to the federal level (COFINS, PIS-PASEP, CPMF and IOF) by a new federal VAT whose proceeds are not shared with sub national governments. This reform will not modify the jurisdiction of the current dual VAT system. Neither will it touch the 1988 intergovernmental revenue-sharing agreements, thereby not altering the amount of disposable revenues available to sub national governments. With the fiscal federalist restriction not being binding, the implementation of this proposal will depend only on whether there are still positive macroeconomic gains from this reform even after the imposition of a fiscal adjustment restriction and, above all, on the number of individuals experiencing such gains.<sup>16</sup> The rest of the paper quantifies this analysis using a dynamic CGE model calibrated for the Brazilian economy.

### **III. The Model**

The model used in the tax reform simulations was developed in Auerbach and Kotlikoff (1987). It is an overlapping generation (OLG) model where all agents live for 55 periods. At any point in time the economy is populated by 55 different cohorts. Within each cohort, individuals are identical. Heterogeneity arises only between different cohorts and corresponds to differences in earning abilities or in human capital levels-  $e_t$ . Population growth is exogenous at the rate  $\eta$ . A brief presentation of the model follows below.

#### **A. Preferences and the Individual Budget Constraint**

Individual preferences are time-separable, time-invariant and of the nested, constant elasticity of substitution (CES) form as presented in (1) and (2). They are completely parameterized by  $\gamma$ ,  $\delta$ ,  $\rho$  and  $\alpha$ , respectively defined as the intertemporal elasticity of substitution, the discount rate, the intratemporal elasticity of substitution between consumption and leisure and the utility weight on leisure.

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<sup>16</sup> The revenue yield of the IOF levied on gold is shared with states and is excluded in the analysis.

$$U = \frac{1}{1 - \frac{1}{\gamma}} \sum_{t=1}^{55} (1 + \delta)^{-(t-1)} u_t^{(1-\frac{1}{\gamma})} \quad (1)$$

$$u_t = [c_t^{(1-1/\rho)} + \alpha l_t^{(1-1/\rho)}]^{1/(1-1/\rho)} \quad (2)$$

Each individual chooses a perfect-foresight path of consumption  $\{c_t\}$ , and leisure  $\{l_t\}$ , leaving no bequests and receiving no inheritances in order to maximize a lifetime utility function of the following form. The optimal path of consumption and leisure is subject to a lifetime balanced budget constraint, which requires the present value of lifetime consumption to be smaller or equal to after tax lifetime income. This constraint can be written as:

$$\sum_{t=1}^{55} \prod_{s=1}^t [1 + r_s(1 - \tau_{kt} - \tau_{yt})]^{-1} [w_t e_t (1 - l_t)(1 - \tau_{lt} - \tau_{yt} - \tau_{st}) - (1 + \tau_{ct})c_t] + PVB \geq 0 \quad (3)$$

Where  $r_t$  is the before tax interest rate in period  $t$ ,  $w_t$  is the standardized net wage rate in year  $t$  and  $e_t$  is the level of human capital.  $\tau_k$ ,  $\tau_l$  and  $\tau_c$  are the marginal tax rates imposed on capital income, wage income and consumption, respectively.  $\tau_y$  is an additional tax rate levied on general income, which attempts to capture the burden of taxes whose effective base is neither labor nor capital income but some combination of both. Individuals also contribute to a pay-as-you-go (PAYG) social security system through a tax on corporate payroll ( $\tau_s$ ) expecting to receive an amount PVB in lifetime social security benefits.<sup>17</sup>

## B. Technology

The model has a single production sector. Output is produced by identical competitive firms using the standard Cobb-Douglas form described in (6). Where  $Y_t$ ,  $K_t$ ,  $L_t$  is aggregate output, capital and labor, respectively.  $A$  is the parameter for exogenous technological change and  $\theta$  is capital's share in production.

$$Y_t = AK_t^\theta L_t^{1-\theta} \quad (4)$$

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<sup>17</sup> Even though none of the tax reform experiments will involve modifications in the social security system, its inclusion is justified on the basis that it presents an additional burden in the tax system, which needs to be taken into consideration before tax reform experiments are implemented.

By invoking the standard assumption that capital is owned by individuals and supplied every period to firms along with labor, firms' profit maximization is static. Competitive pre-tax wages and interest rates are thus given by the marginal product of labor and capital, respectively.<sup>18</sup>

$$r_t = \theta A(K_t/L_t)^{\theta-1} \quad (5a)$$

$$w_t = (1-\theta) A(K_t/L_t)^\theta \quad (5b)$$

### C. Government

Government performs two roles in the model. The first is to manage its central budget. At any time  $t$ , the government collects tax revenues  $-T_t$  - levied on consumption and on both labor and capital income -  $T_t = (\tau_{lt} + \tau_{yt}) w_t L_t + \tau_{ct} C_t + (\tau_{kt} + \tau_{yt}) r_t K_t$ . Such taxes are used to finance government purchases of goods and services ( $G_t$ ). The government also administers a pay-as-you-go (PAYG) social security system. Payroll taxes levied on cohorts aged 1 to 45 (working individuals) -  $S_t$  - are used to generate benefits paid to cohorts aged 46 to 64 (retired individuals). Benefit payments are computed by discounting a worker's average earnings over a pre-established period ( $AIME_{t,t-j}$ ) by an earnings to benefit replacement rate ( $R_t$ ) summarized in (6).

$$B_{t,t-j} = R_t \cdot AIME_{t,t-j} \quad (6)$$

Any government spending on goods and services or social security benefits ( $B_t$ ) beyond the resources collected through the tax or social security system are financed by an increase in public debt ( $D_{t+1} - D_t$ ). Increases in the level of public debt are also aimed at servicing the inherited stock of debt ( $r_t D_t$ ) as presented in (7).

$$D_{t+1} - D_t = G_t - T_t + B_t - S_t + r_t D_t \quad (7)$$

It is assumed that in each period, the social security system is self-financed through payroll taxes and, therefore, completely independent of the central government budget.<sup>19</sup> In addition, the government faces a fiscal adjustment restriction under which the consolidated outstanding debt of the public sector cannot increase – i.e.  $D_{t+1} = D_t$ . Under this constraint,

<sup>18</sup> The model assumes that only individuals are taxed. Appendix I will relax this hypothesis by imposing taxes on corporate revenues and deriving its equivalence with individual taxes defined above.

<sup>19</sup>  $S_t = \tau_{st} \sum_{j=1}^{55} w_{t,j} (1 - l_{t,j}) / (1 + \eta)^{j-1} = \sum_{j=0}^9 B_{t,t-j} / (1 + \eta)^{45+j} = B_t$

described in equation (8) below, the government is forced to generate a primary fiscal surplus ( $T_t - G_t$ ) large enough to service all the existing debt.

$$T_t - G_t = r_t D_t \quad (8)$$

#### D. Equilibrium and Simulation Methodology

The equilibrium in this model is of the rational expectations variety, which in the absence of uncertainty implies perfect foresight. Individuals choose lifetime sequences of consumption, leisure and savings given their beliefs of current and future wages, interest rates and tax rates. Given their beliefs about the same variables, firms choose in each period their optimal levels of capital and labor. Government's projected path of tax schedules must satisfy its intertemporal budget constraint. Given the behavior of each sector above, markets for labor and capital must clear when ex-ante price beliefs are exactly the same to the ex-post-observed equilibrium price sequences.

The equilibrium path is obtained numerically with a Gauss-Seidel algorithm. A brief sketch is presented below ( see Auerbach and Kotlikoff 1987 for a detailed analysis). The calculation of the equilibrium path, given a particular parameterization, can be divided in two stages: (i) solving for the steady-state of the economy before the fiscal reform; (ii) solving for the transition path and final steady-state to which the economy converges after the fiscal reform. In both cases the calculation starts with a guess for certain key variables and then iterates on these variables until a convergence criteria is reached. Whereas in (i) the algorithm consists of choosing an equilibrium allocation, in (ii) the algorithm finds an equilibrium time path of allocations. The algorithm for (i) is just a special case of (ii), which is described in more detail below.

Aggregate variables of the model are solved with a forward-looking algorithm that iterates on the capital stock and labor supply over the entire transition path. An initial guess is made for the time-paths of these variables, shadow wages, shadow tax rates and endogenous average and marginal tax rates. The model then calculates the corresponding factor prices and forward-looking consumption, asset and leisure choices for each current and future cohort. Shadow wages and shadow taxes are calculated to ensure that the time endowment and the tax constraints discussed above are satisfied. Individuals' labor supply and assets are then aggregated by age at each period of time. This aggregation generates a new value for the time path of the capital stock and labor supply.

Tax rates are set exogenously in the initial steady-state. The level of government expenditures in the initial steady state -  $G^*$ - is determined endogenously in order to satisfy the balanced budget requirement in this period.<sup>20</sup> It is held fixed at its steady-state value

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<sup>20</sup> Let  $t=0$  be the initial steady state where  $D_{t+1}=D_t=D_0$ ,  $T_t=T_{t+1}=T_0$ ,  $r_t=r_{t+1}=r_0$ . This implies that  $G_t=G_{t+1}=G_0=T_0-r_0D_0$ .

throughout the transition path ( $G_t=G^*$ ). The simulation procedure also calculates endogenously the payroll tax necessary to finance the retirement benefits. The algorithm then iterates until the capital stock and labor supply time-paths each converge. After 150 years the algorithm constrains all prices, tax rates and allocations to be constant.

### **E . Tax Reform Experiment**

The tax reform experiment is defined under the A-K model as the replacement of corporate revenues and financial transaction taxes by a flat broad-based federal VAT. Taxes on corporate revenues and financial transactions can be reduced to a tax on general income – i.e. a tax levied on both capital and labor income whose separate incidence among both factors cannot be identified. Appendix I demonstrates the equivalence between taxes on corporate revenues and a general income tax. The general income nature of financial transaction taxes stems from the fact that they are levied on remunerations to both capital and labor factors that cannot be easily disentangled.<sup>21</sup> Therefore, the proposed reform can be seen as a partial switch from an income to a consumption based tax system.

The timing of this experiment is as follows. Assume the economy rests in a steady state at the initial period ( $t=0$ ) and the government runs a balanced budget. A group of policymakers wants to implement the tax reform described above on an once and for all basis in the following year. They face two different set of restrictions: (i) the overall level of the public sector debt cannot increase beyond its steady-state level ( $D_{t+1}=D_t=D_0$ ) and (ii) the level of government expenditures cannot decrease, being fixed at its initial steady-state value ( $G_t=G_{t+1}=G_0$ ). Restrictions (i) and (ii) correspond to the fiscal adjustment restriction and, when combined, they imply that the overall level of tax revenues raised by the public sector has to be large enough to finance the level of total expenditures observed in the initial steady state as well as to service the remaining debt (i.e.  $T_t=G_0 + r_tD_0$  or, alternatively,  $T_t-G_0= r_tD_0$ ). In standard policymaking jargon this corresponds to a regime of zero operational deficits or primary surpluses large enough to pay for the service of the existent stock of public debt. For the purpose of our tax experiment this implies that the average consumption tax rate is set endogenously through the transition path in order to raise the necessary amount of revenues compatible with the fiscal adjustment restriction. Note that the required amount of tax revenues after the reform is endogenous and increasing with respect to the level of interest rates obtained along the equilibrium path.

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<sup>21</sup> More than 60 percent of all tax revenues collected between 1994 and 1998 were from taxes levied on bank deposits (CPMF) reflecting payments to both capital and labor input factors.

#### IV. Model Parameterization and Calibration

Effective tax rates, demographic and technology parameters were estimated using Brazilian data. Preference parameters estimated from Brazilian data derived in previous work were used whenever available. The model was calibrated for the most part to match averages between 1995/2002. A couple of variables such as the real interest rate, the total tax burden and the net debt of the consolidated public sector presented a clear non-stationary behavior. In order to avoid softening the fiscal adjustment restriction, the model was calibrated to match variables at the end 2002. Details on the parameterization and calibration of the A-K model are presented in Appendix II. Table 1 summarizes the final parameterization and Table 2 the fit between simulated and observed variables.

Table 1. Benchmark Parameter Definitions and Values

<i>Symbol</i>	<i>Definition</i>	<i>Value</i>
$e_t$	Earnings Ability Profile $e_t = \exp(a + bt + ct^2)$	a/b/c -0.231/ 0.0529/- 0.000934
$\eta$	Population growth	0.019
$\rho$	Elasticity of substitution b/w consumption and leisure	1.15
$\gamma$	Intertemporal elasticity of substitution in consumption	0.40
$\alpha$	Weight preference for leisure	0.25
$\delta$	Intertemporal discount rate	0.021
A	Technology parameter	1.00
$\theta$	Capital share in income	0.50
Taxes in initial steady-state : $\tau_i$ $i=c,y,k,l$ (In percent)		
$\tau_c$	Consumption tax rate	16.8
$\tau_y$	General income tax rate	13.4
$\tau_k$	Capital income tax rate	9.5
$\tau_l$	Labor income tax rate	8.0

Table 2. Initial Steady-State (In percent of GDP)

Variables	Brazil	Model
Consumption	61.1	63.1
Savings	6.2	5.6
Capital	300	294
Interest rate	12.8	15.2
Total Tax Burden	35.6	35.4
of which Social Security Contribution	5.3	4.7
Public Debt	55.5	58.7

## V. Simulation Results

Given the model parameterization above, replacing taxes on corporate revenue and financial transactions by a new federal VAT would ultimately correspond to a decrease in the effective income tax rate from 13.4 percent to 4.8 percent.<sup>22</sup>

This proposed tax reform experiment will be evaluated first and foremost for its macroeconomic impacts. Final steady states and transition path values of real variables such as saving rates, national income and physical capital along with wages and interest rates will be analyzed. The main goal here is to assess whether the positive growth effects following the replacement of income taxes by consumption taxes are still observed under an environment of fiscal adjustment. As a preliminary way to analyze the distributive impact of the reform, remainder of lifetime utility levels will be computed with the purpose of identifying the welfare winners and welfare losers after the reform.<sup>23</sup>

### A. Macroeconomic Effects

Simulations predict an increase in the stock of physical capital, an increase in the supply of labor and an increase in output throughout the transition between steady states. Table 3 and Figure 2 below illustrate the results. Most of the impact of the reform was concentrated in the first years of the transition.

A partial switch to a consumption tax system generates significantly more long run capital formation than the level observed in the previous system. Net private savings presents a substantial increase of 45 percent in the first year jumping from 6.2 to 9 percent of GDP. It decreases afterwards but still presents a long run increase of 13 percent. The consumption rate decreases in the first year by 4 percent, slowly increasing in the next ten years to finally reach a long-run level 2 percent larger than in the initial steady state. The average consumption tax rate soared by 60 percent in the first years (see Figure 2 b), slowly decreasing in the remaining years to a value still 48 percent higher than the initial steady-state. After an almost imperceptible decrease in the first year, the capital-output ratio increased steadily to a level 7 percent higher than the initial steady-state after 50 years. The growth in the capital-output ratio was followed by a gradual decrease in interest rate. The total number of hours worked in equilibrium (labor) remained stable resulting in an increasing the capital-labor ratio and leading to a continuous increase in wages.

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<sup>22</sup> The effective general income tax rate is obtained after subtracting the burden of taxes on corporate revenue and financial transactions from the respective rate obtained in the steady-state. This burden amounted to 8.6 percent during the same period and was computed by dividing the tax revenues generated by corporate revenue and financial transaction taxes - 6.5 percent of GDP by the effective tax base for general income as detailed in Table A-2 in Appendix II.

<sup>23</sup> A more comprehensive analysis should also take into consideration the intragenerational distributive impact of the reform.

Table 3. Macroeconomic Effects – Summary of Selected Variables

Number of Years after reform	0	1	2	3	4	5	6	7	8	9	10	50	150
<b>Real Variables 1/</b>													
GDP	1.00	1.00	1.01	1.01	1.02	1.02	1.02	1.03	1.03	1.03	1.04	1.09	1.09
Capital	1.00	1.00	1.00	1.00	1.01	1.01	1.01	1.02	1.02	1.02	1.03	1.07	1.08
Consumption	1.00	0.96	0.97	0.97	0.97	0.97	0.98	0.98	0.98	0.98	0.98	1.02	1.02
Net Savings	1.00	1.45	1.43	1.42	1.40	1.39	1.38	1.35	1.34	1.33	1.32	1.13	1.13
Labor	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
Wages	1.00	1.00	1.00	1.00	1.01	1.01	1.01	1.02	1.02	1.02	1.03	1.07	1.07
Interest Rates	1.00	1.00	1.00	1.00	0.99	0.99	0.99	0.98	0.98	0.98	0.97	0.93	0.93
<b>Composition of GDP 2/</b>													
Consumption	63.1	60.8	61.0	61.1	61.3	61.4	61.6	61.7	61.8	62.0	62.1	64.1	64.1
Net Savings	6.2	9.0	8.9	8.8	8.7	8.6	8.5	8.4	8.3	8.3	8.2	7.0	7.0
Government expenditures	26.5	27.0	26.8	26.6	26.4	26.3	26.1	26.0	25.8	25.7	25.5	23.5	23.2
Total Tax Revenues	35.4	36.0	35.8	35.6	35.4	35.2	35.1	34.9	34.8	34.6	34.5	32.4	32.1
Consumption tax revenues	15.7	25.5	25.2	24.9	24.7	24.4	24.2	23.9	23.7	23.5	23.3	20.2	19.8
Public Debt	58.8	58.5	58.7	58.9	59.2	59.4	59.6	59.8	59.6	59.8	59.9	63.1	63.1

Notes: 1/ Normalized by initial steady-state values and set as percentage of GDP

2/ Selected variables as percentage of GDP

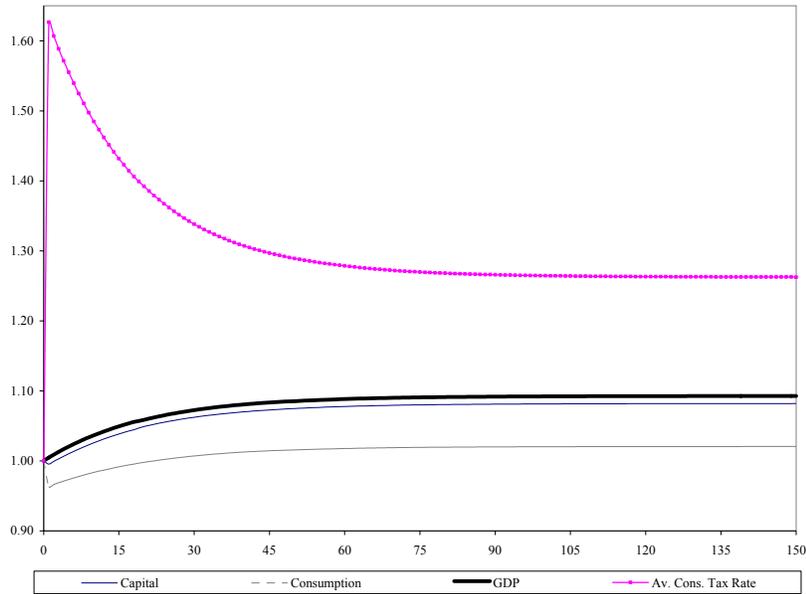
The macroeconomic results above are driven by two important factors: the life cycle implied by the A-K model and the fiscal adjustment restriction. The life cycle structure embedded in the A-K model implies different propensities to consume and save across generations. Older generations, being closer to the end of their lifetime, present, *ceteris paribus*, a larger marginal propensity to consume (a smaller marginal propensity to save) than younger generations. The fiscal adjustment restriction basically implies that the total amount of resources the tax system extracts from the private sector should depend on the dynamics of the interest rate. A decreasing interest rate will require that a smaller amount of resources in the form of taxes be extracted from the private sector in order to keep the debt level constant in nominal terms.

Intertemporal consumption decisions and static fiscal adjustment restrictions impact real variables through the usual income and substitution channels. A once and for all decrease in income taxes and its replacement with a consumption tax under the fiscal adjustment restriction will present an unambiguously positive effect on the level of income reflecting both a positive income and substitution effect on savings.

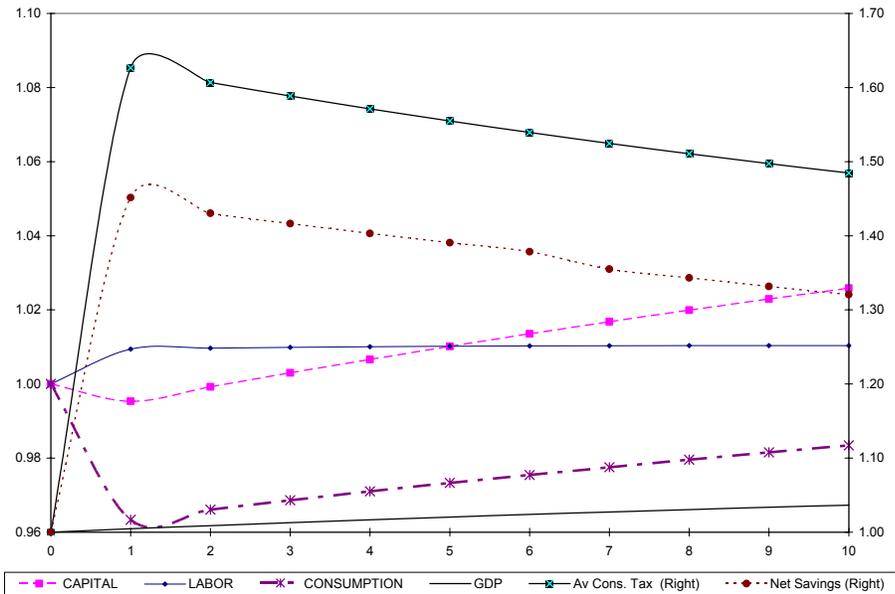
Starting with the income effect, let's first assume that the interest rate is set constant between steady-states. In that case, the amount of taxes extracted from the private sector before and after the reform is the same and, because of that, there are no overall income effects.

Nevertheless, there are still individual income effects, which can be positive or negative depending on how lifetime income is affected by the tax reform. Younger generation's higher marginal propensity to save implies that a larger amount of taxes will be paid further in the future. While at the end they are still going to pay the same amount of taxes they used to pay before the reform, under the new system, tax payments can be postponed to the future and thus present a lower present value increase in their lifetime and current income. The gain to

Figure 2. Macroeconomic Effects



(a) Long Run Effects



(b) Short-Run Effects

younger generations contrasts with the loss to older generations. Having already financed most government expenditures through income taxes during their working years, older cohorts will now have to contribute in the form of higher consumption taxes more than they were supposed to pay after retirement relative to the previous tax system. But the income effect described above is not the only force driving the increase in aggregate income, savings

and capital promoted by the reform. The positive income effect on the young and future cohorts is compounded by a positive substitution effect of higher after tax interest and wage rates resulting from the reduction of the general income tax. As a result of that, the reform induced those individuals to procrastinate their consumption even further in order to take advantage of future lower after tax prices.

The rationale above is basically the same if the interest rate is allowed to change. Under an increasing interest rate, however, the positive discounting effect on the young may be more than compensated by a negative level effect implied by a larger tax bill. As a result the overall income effect may be negative. However, if the intertemporal substitution effect between consumption now and in the future is larger than the intratemporal substitution effect between labor and leisure, an increase in the capital-labor ratio would induce a decrease in the second period interest rate. A decreasing path will thus reinforce growth through a positive income effect increasing capital and income even further.

This seems to be the case in our simulation given that an increase in the levels of capital and income is also followed by a relatively stable employment level, a slight decrease in interest rate and an increase in the capital labor ratio, which in turn induces an increase in the wage rate. A decrease in the interest rate also implies a decrease in the debt service and hence, a declining volume of consumption taxes necessary to meet the fiscal adjustment restriction.

The path for aggregate share of consumption to GDP - illustrated in Figure 2 - also reflects the rationale exposed above. In the initial periods of the transition, consumption decreases due to the negative income effects on older generations who should be responsible for the larger percentage of the consumption at that time as well as from the negative substitution effect of young generation delaying an even larger share of consumption to the future. As times goes by and the generation who were young at the time of the reform start to increase their participation in aggregate consumption. Given the tax reform positive income effects they will consume more than they would have consumed had the tax reform not been implemented. The result is an increasing consumption.

Summing up, the results presented above seem to indicate that the expected long-run positive growth effects of switching to a consumption-based system commonly obtained in the literature are replicated for the Brazilian economy. The imposition of the additional fiscal adjustment condition does not compromise the long-run results. Neither does it impose short-run costs in terms of a substantial decrease in employment or income for the first years of the transition.<sup>24</sup>

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<sup>24</sup>This result was robust to alternative initial levels of interest rates as well as to different values for the structural parameters. Additional tax reform experiments have also confirmed the consumption tax base as the best replacement for taxes on corporate revenues and financial transactions under a fiscal adjustment program. Given space constraints, these results along with the sensitivity analysis are available upon request.

## B. Welfare Effects

In order to assess the distributive impact of the reform, lifetime expected welfare changes (LTWE) resulting from the tax reform implementation were computed for each cohort. LTWE is defined as the fraction of the remaining full lifetime labor endowment required under the original tax regime to produce each cohort's realized level of utility under alternative tax regimes.<sup>25</sup> A number higher than one means that the representative individual in that cohort will need more than the total amount of her full lifetime endowment to produce the level of utility after the reform. This implies that the individual would expect to experience a welfare gain if the proposed tax reform is implemented and would presumably be in favor of the reform.

The distribution of LTWE is depicted in Figure 3. The horizontal axis orders individuals according to the number of years born before the reform. It ranges from -54, (individuals born 54 years before the reform and with one more year of life left after it) to 0 (individuals born at the year the reform is proposed). The left hand side vertical axis measures changes in lifetime wealth experienced by each individual. The line in the model combines individuals' age and their respective change in welfare. The cumulative distribution function of the population represented by bars in the same figure is measured on the right hand side vertical axis.<sup>26</sup>

It is clear from this figure that generations born at least 30 years before the reform will face a decrease in their remaining full lifetime income after the reform (LTWE is smaller than 1). This group that corresponds to little more than 30 percent of the living population. The remaining 70 percent of the population are composed of individuals from generations born at most 31 years before the reform, who, on the other hand, will experience an increase in their full lifetime income. This result seems to indicate that the positive macroeconomic effects of the proposed reform are relatively well spread across the population even after accounting for the large increase in average consumption tax rates required by the fiscal adjustment restriction.<sup>27</sup>

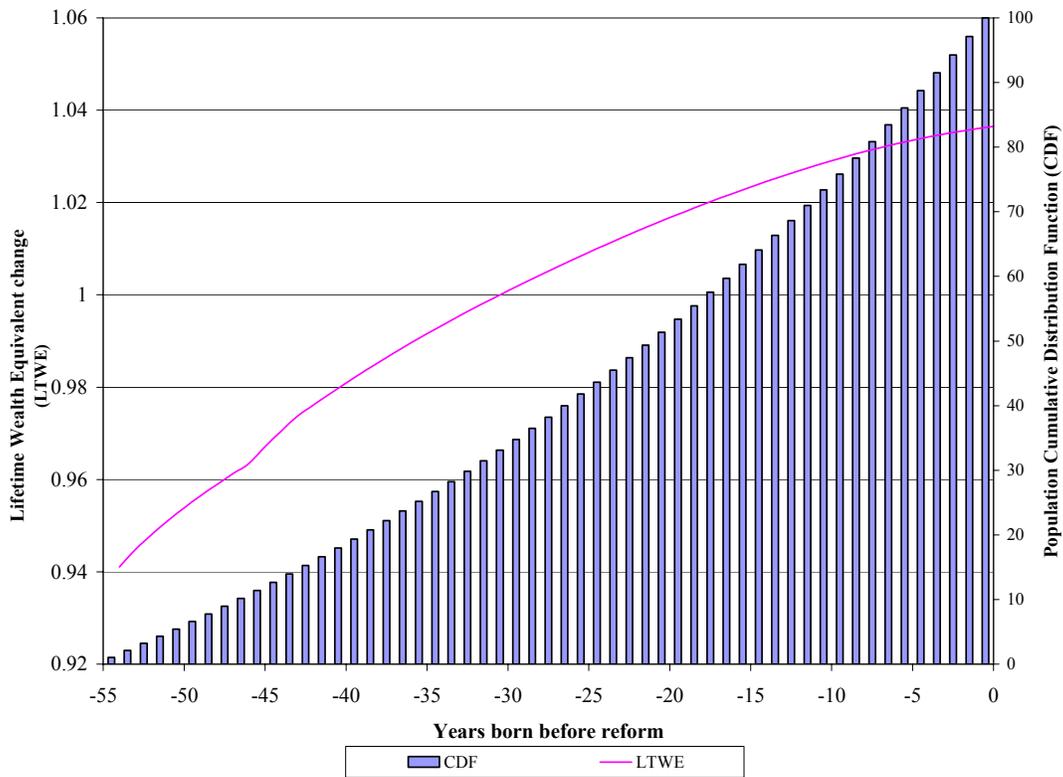
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<sup>25</sup> The measure is basically an equivalent variation measure of lifetime changes in welfare.

<sup>26</sup> The population distribution function is based on a population growth of approximately 2 percent, the same figure used in the model parameterization.

<sup>27</sup> Whether the widespread positive welfare effects of the reform will imply its implementation in a representative democracy is a much more complicated issue. Factors such as the lobbying organization or the political power of the losing minority along with the size of the majority required to approve the reform, which go beyond the scope of the current model, would have to be considered.

Figure 3. Intergenerational Welfare Effects



## VI. CONCLUSIONS

Using the Auerbach and Kotlikoff (1987) dynamic model calibrated for the Brazilian economy, this paper has shown that distortionary taxes on corporate revenues and financial transactions could have been replaced on a once and for all basis by a new consumption tax under a non increasing path for the consolidated net debt of the public sector without compromising Brazil's income growth prospects. Tax reforms simulations have not involved any substantial short-run decrease in income, the supply of labor or in the stock of capital. Neither were interest rates increased nor wages depressed. Moreover, the proposed tax reform generated positive welfare gains for 70 percent of individuals.

This paper has also contributed to the CGE literature on the macroeconomic impacts of alternative tax systems. Increasing the reliance on consumption taxes has proved to be growth, and welfare-enhancing even when governments cannot increase public debt in order to alleviate part of the increasing tax incidence on older generations with a smaller tax burden.

The above results have provided some initial evidence that fiscal adjustment could not have been posed as an obstacle to the implementation of a more efficient tax system during President Cardoso's administration even if the proposed system is implemented in a once and for all basis. Given the recent elimination of the federal turnover taxes, an immediate extension would be to compare the macroeconomic and distributive impacts of an once and for all elimination proposed here by the more gradual approach undertaken at the end of President Cardoso's administration (elimination of turnover taxes followed by financial transaction taxes).

More refined analysis should also attempt to incorporate intragenerational heterogeneity and uncertainty in the dynamic general equilibrium framework of the A-K model in order to present a more complete assessment of the distributive impacts of the tax reform under fiscal adjustment programs. On-going research on the macroeconomic and distributive impact of the U.S. tax reform has proved some of these extensions feasible.<sup>28</sup>

Future research should also check the robustness of these results by examining multisectoral dynamic models with the objective of capturing not only the distortions imposed on savings-investment decisions captured here, but also intrasectoral distortions on production methods that may have an impact on external competitiveness. Additional studies could also attempt to incorporate the isolated impact of financial transaction taxes on savings-investment decisions via increases in interest rate spreads and by hampering financial development.<sup>29</sup>

Above all, the political feasibility of the reform should be tackled more directly by identifying key actors (individuals or sectors) and appropriate computational procedures capable of mapping individual preferences into voting outcomes.<sup>30</sup>

Last, but not least, future studies should replicate and extend this analysis for other Latin America countries. In light of the persistency of distortionary features in Latin American tax systems and on the central role fiscal adjustment will continue to play to mitigate the risks of an increasing public debt, such research agenda is already overdue.

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<sup>28</sup> See Altig et al (2001) for extensions of the A-K model that incorporate intragenerational heterogeneity with the objective. Using a similar structure to the A-K model that allows for the incorporation of idiosyncratic shocks to labor earnings and lifetime spans, Engen and Gale (1997) and Nishiyama and Smetters (2003) simulate the replacement of the current U.S. income based tax structure with a flat income tax. In both exercises tax reform is carried on under the assumption of standard revenue neutrality.

<sup>29</sup> See Suescun (2003) for an initial exercise in this direction.

<sup>30</sup> There are still no consensual computational procedures capable of aggregating preferences according to any given voting or political mechanism and at the same delivering a solution to an overlapping generation model. See Krussell, Quadrini and Rios-Rull (1997) for a discussion of some initial attempts on infinitely-lived representative agent models.

## APPENDIX I. Equivalence Between Taxes on Corporate Revenues and a Tax on General Income

The equivalence between taxes on corporate revenues and a tax on general income is obtained by comparing households first order conditions in equilibrium and evaluated at the steady-state in two different cases. The first case assumes that only households are taxed. In the second, taxes are levied on firms only. Households' contemporaneous marginal rate of substitution between leisure and consumption and intertemporal marginal rate of substitution in consumption today –Euler equation – are computed and contrasted among cases.

### Case 1: Taxes on individuals only.

Skipping the derivation and explanation of first order conditions, which are presented in detail in Auerbach and Kotlikoff (1987), leads us to the equality between marginal ratio of substitution and prices collected in (A-1) and (A-2) below. While, the former equates the contemporaneous substitution between consumption and leisure to the relative prices, the latter involving the intertemporal substitution between consumption today and tomorrow (Euler Equation).<sup>31</sup>

$$\frac{l_t}{c_t} = \left( \frac{w_t^* (1 - \tau_{ht})}{\alpha (1 - \tau_{ct})} \right)^{-\rho} \quad (\text{A-1}) \qquad \frac{c_t}{c_{t-1}} = \left[ \frac{(1 + r_t (1 - \tau_{kt})) (1 + \tau_{ct-1})}{(1 + \delta) (1 + \tau_{ct})} \right]^\gamma [v_t / v_{t-1}] \quad (\text{A-2})$$

Where  $v_t = [1 + \alpha^\rho (w_t^* (1 - \tau_{ht}))^{1-\rho}]^{(\rho-\gamma)/(1-\rho)}$ ,  $w_t^* = w_t e_t + \mu_t$  and  $\mu_t$  is the shadow wage in year t.

Firms are not taxed, which implies that the first order conditions for the problem of the firms are exactly the same as those derived in the model. Equations (A-3) and (A-4) recall those first order conditions.

$$r_t = \theta A (k_t)^{\theta-1} \quad (\text{A-3})$$

$$w_t = (1-\theta)A (k_t)^\theta \quad (\text{A-4})$$

Where  $k_t = K_t/L_t$

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<sup>31</sup> By plugging (A-1) into (A-2), Auerbach and Kotlikoff (1987) also derived the Euler equation for leisure, which is just a monotonic transformation of the Euler equation for consumption not playing any additional role in our equivalence derivation.

Plugging (A-3) and (A-4) into (A-1) and (A-2) and evaluating them at the steady-steady.<sup>32</sup>

$$\frac{l}{c} = \left[ \frac{\left( (1-\theta)A k^\theta e + \mu \right) (1-\tau_h)}{\alpha(1-\tau_c)} \right]^{-\rho} \quad (\text{A-5})$$

$$1 = \left[ \frac{1 + (\theta A k^{\theta-1})(1-\tau_k)}{(1+\delta)} \right]^\gamma \quad (\text{A-6})$$

**Case 2: Taxes on firms only.**

Marginal rates of substitution for the case when just firms are taxed are identical to the previous one except that after tax prices are identical to before tax prices. One would need just to rewrite (A-3) and (A-4) by setting all taxes equal to zero.

$$\frac{l_t}{c_t} = \left( \frac{w_t^*}{\alpha} \right)^{-\rho} \quad (\text{A-7}) \quad \frac{c_t}{c_{t-1}} = \left[ \frac{1+r_t}{(1+\delta)} \right]^\gamma [v_t / v_{t-1}] \quad (\text{A-8})$$

Where  $v_t = [1 + \alpha^\rho (w_t^*)^{1-\rho}]^{[(\rho-\gamma)/(1-\rho)]}$

The basic change will be on the firm first order conditions. Recall that the problem of the firm consists basically of the static maximization of profits, after tax profits if they are taxed. Under the latter case the firm optimization problem can be rewritten as follows:

$$\text{Max } Y_t - w_t L_t - r_t K_t - T_t \quad (\text{A-9})$$

Where  $T_t$  is the total amount the firm has to pay in taxes. It can assume different forms, depending on the incidence base. In this simple model, we are going to consider only one base: corporate revenues. Suppose that firms are taxed at a proportional rate  $\tau_p$ .

$Y_t$ , the total amount of the final good produced by the firm, in equilibrium can also be seen as the firm revenues. A proportional tax on firm revenues is represented by

$$T_t = \tau_{pt} Y_t \quad (\text{A-10})$$

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<sup>32</sup> Time subscripts are omitted to indicate that the variable is evaluated at the steady state.

First order conditions for the firm problem are now obtained by solving (A-9) subject to (A-10). Input factor prices are now

$$r_t = (1 - \tau_{pt}) \theta A (k_t)^{\theta - 1} \quad (\text{A-11})$$

$$w_t = (1 - \tau_{pt}) (1 - \theta) A (k_t)^{\theta} \quad (\text{A-12})$$

Substituting (A-11) and (A-12) into (A-7) and (A-8) evaluating at the steady state generates the steady-state first order conditions.

$$\frac{l}{c} = \left[ \frac{\left( (1 - \theta) A k^{\theta} e^{(1 - \tau_p)} \right)}{\alpha (1 - \tau_c)} \right]^{-\rho} \quad (\text{A-13})$$

$$1 = \left[ \frac{1 + (\theta A k^{\theta - 1}) (1 - \tau_p)}{(1 + \delta)} \right]^{\gamma} \quad (\text{A-14})$$

(A-13) and (A-14) are identical to (A-5) and (A-6) if and only if  $\tau_p = \tau_k = \tau_h$ .

Taxing corporate revenues is equivalent to imposing a symmetric tax on capital and labor income in the steady state. The implication of that result for the calibration of the Auerbach and Kotlikoff (1987) model is that it suffices to consider an average rate on corporate revenue as an additional tax rate on general income.

## APPENDIX II. Parameterization and Calibration Details

### A. Tax rates

The computation of effective tax rates was based on Mendoza et al (1994) methodology modified to incorporate the details of the Brazilian tax system and the main features of the A-K model. Effective tax rates were calculated to approximate the average burden (tax-GDP ratio) in 2002 of the Brazilian (federal, state and local) tax and social security system. Table A-1 provides a general overview of the evolution of the Brazilian tax burden by statutory base and jurisdiction. The calculation of effective tax rate is presented below with results summarized in Table A-2.

#### Consumption Tax

The consumption tax rate was computed by dividing the GDP participation of tax revenues from all value-added (IPI, ICMS) and excises (ISS, II) taxes by total final consumption expenditures. The consumption tax base includes also the final consumption of the general government in all three levels, which are not exempt from any of the excise or VAT taxes. The result is an average consumption tax rate ( $\tau_c$ ) of 16.8 percent.

### Labor Income Tax

The effective tax rate on labor income was computed after dividing the average tax revenue from all federal taxes and social contributions levied on corporate payroll (FGTS, SED, others) and not used to finance retirement pensions in the social security system by the aggregate payroll.<sup>33</sup> The resulting effective tax rate was 8 percent.

### Capital Income Tax

An average tax rate on capital income was calculated by dividing tax revenues on income, profits and capital gains of corporations by the total operating surplus of the economy leading to a 9.5 percent average tax rate on capital income.<sup>34</sup>

### General Income Tax

The total burden on income is finally computed with the calculation of an effective tax rate on general income. Included in this group are taxes on income, profits and capital gains of individuals, taxes on property and financial transactions.<sup>35,36,37</sup>

We have also included in this group taxes on corporate revenues and financial transactions (COFINS, PIS/PASEP, IOF, CPMF), which, as shown in Appendix I, are equivalent to a symmetric tax on labor and capital income.

The average tax on general income was obtained after dividing the average revenues from all taxes described above by the after tax net domestic income, defined as the remuneration

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<sup>33</sup> Aggregated payroll is defined as the sum of wages and salaries and self-employed remuneration. The former is also included as payroll taxes are also levied on self-employed occupations.

<sup>34</sup> Mendoza et al assign all self-employed income to capital. I assign all self-employed income to labor given that most of it is generated from small labor-intensive unincorporated enterprises (physicians, attorneys, etc).

<sup>35</sup> Tax on personal income: IRPF. Taxes on property: IPTU, ITR, ITBI. Taxes on financial transactions: CPMF, IOF.

<sup>36</sup> The incidence of property tax on production factors is still an unresolved issue. At the macroeconomic level, there seems to be an understanding that a property tax on structures would be equivalent to a capital income tax (Zodrow and Mieszkowski 1972). In order to adopt a more conservative stance, general income was used as the base for property taxes. Nevertheless, given the small participation of property tax revenues in the total (5.26 percent), it is unlikely that any reparameterization towards capital income would alter the results substantially.

<sup>37</sup> More than 60 percent of all tax revenues on financial transactions are from taxes levied on bank deposits (CPMF), reflecting payments either to capital, labor or both. Arbitrage conditions between banking and non-banking mediated payments to factor inputs would affect the return of both labor and capital rendering this tax equivalent to a tax on general income.

of employed (wages) and self-employed workers plus the total operational surplus. The result is an average tax on general income equal to 13.4 percent.<sup>38</sup>

### **B. Social Security Benefits and Contribution**

The model was calibrated to set social security benefits equal to social security contributions in the steady-state. The replacement rate was set to 100 percent leaving AIME to be defined by the average wage received by the retired worker over its productive lifetime. Both features will represent just an initial approximation by the Brazilian social security system, but one that should be able to capture the tax burden dynamics it imposes on the private sector while at the same time singling out the social security tax from the remaining taxes on labor income due to its immediate connection with future benefits.<sup>39</sup> The social security payroll tax used to finance retirement pensions of the social security system was computed separately from other payroll taxes as required in the A-K model. Revenues from contributions to the PAYG social security fund made by employers, employees and self-employed individuals were divided by total wage earnings. The tax base for the social security payroll tax differs from the base from other payroll taxes by the inclusion of employers' social security contributions and other fringe benefits. An effective tax rate ( $\tau_s$ ) of 10.4 percent was obtained.

### **C. Demographics: Population Growth rate and Earnings-Ability Profile.**

Population growth ( $\eta$ ) was set equal to 1.9 percent, its historical average up until 1998. An individual's earning ability or human capital profile is an exogenous and stationary function of her age. Auerbach and Kotlikoff (1987) have parameterized this profile as an exponential function of years of experience and its square:

$$e_t = \exp ( a + bt + ct^2 ) \quad (A-15)$$

Having this functional form specification as the starting point, Ferreira (2001) estimates the returns on experience for urban male workers between 25 and 65 years old using the Brazilian Survey of Household Samples (PNAD). After controlling for time, geographical

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<sup>38</sup> Under Mendoza et al's methodology the next step would have been to use this rate in order to discriminate tax revenues on general income levied on capital from those levied on labor and their inclusion on the formula for the effective tax rates on capital and labor income, respectively. This imputation is usually debatable for it requires the assumption of a symmetric treatment between labor and capital income. For that reason and given that the A-K model allows an effective tax on general income to coexist with separate taxes on capital and labor, I have opted to maintain this tax as an additional parameter in the model.

<sup>39</sup> In Brazil,  $AIME_{t,t-j}$  is calculated based only on the three years previous to eligibility for benefits. In addition, eligibility for benefits is fulfilled either when a person works for 35 years – the “length-of-service” (LS) pension – or turns 66 years old (46 in the model) – the standard old-age (OA) benefit. Replacement rates are set at a minimum of 70 percent in Brazil increasing with years of contributions (an additional 1 percent per year of contribution under the OA and an additional 6 percent per year of contribution after 30 years in the LS). See Ferreira (2001) for a more comprehensive treatment of the Brazilian social security system and its macroeconomic effects using the A-K model.

and school level effects, he obtains estimates for a, b and c respectively equal to  $-0.231$ ,  $0.05$  and  $-0.0009$ , which were used in this calibration.

#### D. Technology

The parameter  $\theta$  in the Cobb-Douglas represents the participation of capital in national income ( $rK = \theta Y$ ). An estimate for  $\theta$  is thus obtained through the multiplication of the interest rate by the capital-output ratio ( $r * K/Y$ ). Using different methodologies and time-series alternative studies found a capital-output ratio for the Brazilian economy approximately equal to three (Hoffman 1992, Araujo and Ferreira 1999). Following Araujo and Ferreira (1999), Barreto and Schymura (2000) and Ferreira (2001) a  $\theta$  equal to 50 percent was used..

The technology parameter A has no effect on the marginal rate of substitution between capital and labor. For that reason and given the absence of any estimate both for developed and developing countries, we have adopted a value equal to 1.<sup>40</sup>

Table A-1: Brazilian Tax System: A General Overview

Statutory Base	Jurisdiction	Tax Burden		
		Average 1968-94	Average 1995-2002	2002
Income, profits and capital gains of individuals (IRPF)	Federal**	2.08	2.25	2.50
Income, profits and capital gains of corporations		1.92	3.45	4.00
IRPJ	Federal**	1.42	2.58	3.10
CSLL*	Federal	0.50	0.86	0.90
Corporate payroll - PAYG retirement contribution		2.09	2.66	2.70
FGTS*	Federal	1.32	1.68	1.70
Civil Servant Contribution*	Federal	0.29	0.36	0.30
SESC/SESI/SENAI (S-system)*	Federal	0.26	0.34	0.40
Salario Educacao (SED)*	Federal	0.23	0.29	0.30
Social Security PAYG retirement contribution (INSS)	Federal	4.70	5.06	5.30
Corporate revenues/turnover		1.25	3.91	4.70
COFINS*	Federal	0.42	3.01	3.80
PIS/PASEP*	Federal	0.83	0.90	0.90
Property		0.20	0.88	1.10
Urban property (IPTU)	Local	0.20	0.46	0.50
Others (Rural Property- ITR, Property Transmissions -ITBD)	Federal**/State and Local	0.00	0.42	0.10
Vehicle License Registration (IPVA)		0.10	0.44	0.50
Financial and capital transactions		0.53	1.55	1.80
Financial and Exchange Rate transactions (IOF)	Federal	0.53	0.39	0.30
Bank Account Deposits (IPMF/CPMF)*	Federal	0.00	1.16	1.50
Consumption of goods and services		12.31	11.02	13.50
Value-Added Tax on Manufacture Products (IPT)	Federal**	2.85	1.73	1.40
Value-Added Tax on Goods and Services (ICMS)	State	5.86	7.55	7.80
Sales on selected goods (incorporated to ICMS after 1988)	Federal	2.50	0.00	0.00
Sales tax on services (ISS)	Local	0.29	0.58	0.50
(Import Taxes -II) and others	Federal	0.81	0.91	3.80
<b>Total Tax Burden</b>		<b>25.17</b>	<b>30.95</b>	<b>35.60</b>

Sources: IBRE/FGV and Brazilian Development Bank (BNDES), Department of Economics (DEPEC).

Notes: \* Social Contribution, \*\* Tax Revenues shared with states and /or municipalities

<sup>40</sup> Setting A equal to 1 emphasizes the mute role played by technology changes in this model.

Table A-2 : Effective Tax Rate Computation

1) Tax revenues by statutory base (In percent of GDP)	
1.1) Income, profits and capital gains of individuals	2.5
1.2) Income, profits and capital gains of corporations	4.0
1.3) Corporate payroll	2.7
1.4) Social Security Contribution	5.0
1.5) Corporate revenues	4.7
1.6) Property	1.1
1.7) Financial and capital transactions	1.8
1.8) Consumption of goods and services	13.5
2) Tax bases (In percent GDP)	
2.1.0) Household Final Consumption	61.1
2.1.1) Government Final Consumption	19.1
2.2.0) Total Operating Surplus	42.0
2.2.1) Self-Employed Remuneration	6.0
2.3) Wages (Net of employer's social security contribution)	27.6
2.4) Employer's social security contributions and other fringe benefits	14.5
3) Effective Tax Rate = 1)/2)	
General Income [(1.1+1.5+1.6+1.7)/(2.2.0+2.2.1+2.3)]	13.4
Labor income from payroll [1.3/(2.2.1+2.3)]	8.0
Labor income form social security [1.4/(2.2.1+2.3+2.4)]	10.4
Capital Income [1.2/2.2.0]	9.5
Consumption [1.8/(2.1.0+2.1.1)]	16.8

Sources: 1) Tax revenues: Table A-1

2) Tax bases: IBGE- Department of National Accounts, IPEADData

## E. Preference parameters

Estimates of preference parameters for the Brazilian economy are either inexistent or non-consensual. A combination of preference parameters over the range of plausible estimates presented below was used in order to match a set of macroeconomic average estimates assumed to represent the initial steady-state of the economy under analysis. This model calibration technique, which is described in more detail in the next subsection, delivered a very satisfactory matching with values for  $\alpha$ ,  $\rho$ ,  $\gamma$  and  $\delta$  respectively equal to 0.25, 1.15, 0.45 and 0.02.

Estimates for the intertemporal elasticity of substitution ( $\gamma$ ) are very sensitive to the specification of preferences, the frequency of the data and the country of analysis. Values for  $\gamma$  obtained for the US have ranged between 0.10 and 0.45 (MaCurdy 1981, Runkle 1991).<sup>41</sup> Using annual data, Issler and Piqueira (2000) have estimated  $\gamma$  under three alternative preference specifications for the Brazilian economy. Their median estimates have ranged from 0.21 to 0.91.<sup>42</sup> A range between 0.10 and 0.91 was used in the calibration procedure.

<sup>41</sup> MaCurdy estimates  $\gamma$  in an environment without uncertainty and where labor supply is elastic whereas Runkle obtains  $\gamma$  assuming CRRA preferences and an inelastic labor supply.

<sup>42</sup> Issler and Piqueira found a  $\gamma$  equal to 0.21 for the majority of specifications assuming a CRRA preference specification, a  $\gamma$  equal to 0.24 under a Kreps-Porteu preference and a  $\gamma$  equal to 0.91 under a habit formation specification.

There are no estimates of the intratemporal elasticity of substitution between consumption and leisure ( $\rho$ ) and the intratemporal weight preference for leisure ( $\alpha$ ) for Brazil. In fact little is known of both parameters even for the U.S. economy. A  $\rho$  equal to 0.83 estimated in Ghez and Becker (1975) is one of the few references cited. Auerbach and Kotlikoff (1987) make no mention of any estimate for  $\alpha$ .

Some effort was made in order to calculate a Brazilian estimate for the intertemporal discount rate. Araujo and Ferreira (1999) estimated a  $\delta$  approximately equal to 0.07. Issler and Piqueira (2001) found estimates ranging from 0.07 to 0.12.<sup>43</sup> This value is higher than the estimate of 0.03 found for Colombia (Schmidt-Hebbel 1994). It is also higher than the estimate of 0.02 obtained for Chile (Cifuentes 1993). For the U.S. economy, recent estimates have ranged between 0.01 (McGrattan 1994) and 0.06 (Cooley and Prescott 1995). Calibration procedures have considered values for  $\delta$  between 0.01 and 0.12.

## F. Calibration

The A-K model parameterized for the Brazilian economy was calibrated to replicate economic conditions during President's Cardoso's mandate (1995-2002). This is a particularly challenging task given the non-stationary behavior that some real and fiscal variables such as real interest rate, the tax and the debt to GDP ratio have assumed after Brazil's financial crisis in 1999. Details on the computation of each of these variables are presented below. A summary of these estimates is presented in Table 2 in the main text where they are contrasted with their respective calibration outcomes. As a general rule, we have adopted averages between 1995 and 2002 for those variables perceived as stable. Values at end 2002 were used for those perceived as non-stationary.

The real macroeconomic variables selected were those commonly used in CGE analyses: the capital-output ratio ( $K/Y$ ), the individual consumption rate ( $C/Y$ ), the net national savings rate ( $S/Y$ ) and the real interest rate ( $r$ ). The average between 1995-2002 was used in all variables but the real interest rate. The individual consumption rate ( $C/Y$ ), defined simply as the share of GDP consumed by families has been very stable over the last fifty-years. The average between 1995-2002 approximately equal to 61 percent was not so different from this historical trend. The net national saving rate was equal to 6.15 percent. It was computed by subtracting from the gross savings rate- 17.4 percent of GDP- foreign savings in the amount of 1.7 percent of GDP and the depreciation of physical capital estimated to be around 10 percent of GDP.<sup>44</sup> The real interest rate used in the benchmark equilibrium was computed as the difference between annualized Selic interest rate fixed by the Brazilian Central Bank at

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<sup>43</sup> Their intertemporal discount rate was presented as  $1/1+\delta$ . A  $\delta$  equal to 0.07 is presented as an intertemporal discount rate equal 0.93.

<sup>44</sup> A value of 9.8 percent of GDP was obtained by multiplying an estimated depreciation rate of 3.2 percent of the stock of capital by the capital-output ratio of 3.

December 2002 (24.95 percent) and Brazil's December CPI (12.15 percent) being equal to 12.8 percent.

The group of fiscal aggregates included the total tax burden, the social security contribution (Sstax) and the net debt of the consolidated public sector (D/Y). All variables were measured in 2002. As presented in the penultimate row of Table A-1, the total tax burden amounted to 35.6 percent of GDP in 2002 and the social security contribution to 5.7 percent of GDP. During the same period, the net debt of the consolidated public sector, which includes the direct administration of federal, state and local governments along with state enterprises and the public financial sector, amounted to 55.5 percent of GDP, respectively.

Assuming that the effective tax rate, the technology and demographic parameters fixed at the values previously estimated, the calibration of the initial steady-state consisted in trying different combinations of the non-consensual preference ( $\rho, \gamma, \alpha$  and  $\delta$ ) parameters to match macroeconomic variables of the Brazilian economy calculated above. Given the imposition of a non-increasing public sector debt, a general concern in this process was to generate, under the current structure of the Brazilian tax system, a tax burden in the steady-state capable of matching the total outlay requirements of the public sector - i.e. the tax burden capable of balancing the budget. Given the separate role played by the social security system in the A-K model, another general concern was to match the model with the additional burden imposed by the social security system.

Individuals will choose to delay consumption to older ages the higher is their intertemporal elasticity of substitution ( $\gamma$ ) and the lower is the discount rate ( $\delta$ ) implying a higher aggregate level of savings and a higher capital-output ratio. Having that in mind,  $\gamma$  and  $\delta$  were chosen from the range of possible estimates to keep consumption, savings and capital-ratio with levels compatible with those observed in the Brazilian economy. Picking any  $\gamma$  above 0.45, the mid-point for the Brazilian range of estimated values, will require a  $\delta$  smaller than the 0.01, the lower-bound of available estimates, to match Brazil's benchmark variables. A good was achieved by setting  $\gamma$  equal to 0.45 and after increasing  $\delta$  to 0.02, a value identical to that Barreto and Schymura (1997) used in their analysis.

Individual decisions on how much time to allocate between labor and leisure are closely linked to the responsiveness of labor supply to changes in wages ( $\rho$ ) and the importance of leisure for the satisfaction of any given cohort at any given time ( $\alpha$ ). They are supposed to affect the supply of labor at any given time in opposite directions. Therefore, the higher is  $\rho$  and the lower the  $\alpha$ , the higher is the life-cycle labor supply of any given cohort as the wage rate increases. This has also important implications for the effective social security tax. At a higher labor supply, the effective social security tax would have to be smaller. A lower  $\alpha$  and a higher  $\gamma$  would increase the labor supply thereby increasing the base of the social security system (corporate payroll) without increasing the benefits distributed. With that in mind, different combinations of  $\rho$  and  $\alpha$  were attempted to match the social security contribution and benefit rates. The model was able to generate values closer to the Brazilian economy with an  $\alpha$  equal to 0.25 and  $\rho$  equal to 1.15.

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