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Fiscal Policy, Supply Shocks and Economic Expansion in Brazil from 2003 to 2007*

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ABSTRACT

This article has two objectives. The first is to show the impact of distortionary taxes during a period of the economic cycle in Brazil. The second is to show that an explanation for output to grow slower than productivity is the increase in taxes on productive factors: capital and labor. To attain these two objectives, we carried out a study comparing the Brazilian economy with simulated data from the neoclassical model of economic growth with and without distortionary taxes. The empirical results show that the model without taxes predicts stronger growth than observed between 2003 and 2007. This point was addressed using the neoclassical growth model with distortionary taxes. However, this model produces a lower output path than observed. Besides this, both models fail to appropriately account for the behavior of the labor market.

Key Words: growth accounting, total factor productivity, dynamic general equilibrium

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1 INTRODUCTION

This article has two objectives. The first is to show the impact of distortionary taxes on the economic cycle. For this purpose, we discuss the particular case of the expansion of the Brazilian economy between 2004 and 2007. The second aim is to present an explanation for output to grow less than productivity, as observed in Brazil in periods of the 1990s and early 2000s. To attain these two objectives, we carried out a study comparing the Brazilian economy with data simulated from the neoclassical economic growth model with and without distortionary taxes on capital, labor and consumption.

In the economic literature, fiscal policy is always indicated as an important factor determining an economy's output. According to economic theory, tax increases can reduce economic growth (see, e.g., BAXTER; KING, 1993). However, in the literature it is common to analyze the quantitative impact of taxes and changes in public spending assuming lump-sum taxes in the basic neoclassical model of economic growth. According to Easterly & Rebelo (1993), this simplification in the treatment of taxes is due to the difficulty of computing average (or marginal) tax rates on production factors or consumption.[1] The choice of the financing structure of public spending in dynamic models is crucial to the evaluation of its impacts on the economy's trajectory. For example, Baxter & King (1993) show that when expansion of public spending is financed by lump-sum taxes, hours worked increase and real wages decrease. But when this financing occurs through distortionary taxes, hours worked and real wages decline together. This means that distortions matter.

The only way to have more precise measures of the impact of fiscal policy is to assume taxes are distortionary and show their impact on the macroeconomic variables in specific episodes (BURNSIDE; EICHENBAUM; FISHER, 2004). This is what we try to do in this article, by analyzing the impact of a neoclassical model with taxes and showing its ability to reproduce the trajectory of the Brazilian economy during the period of steady expansion from 2003 to 2007.

My analytic strategy is to compare path simulations of the neoclassical model with distortionary taxes with the observed path of the Brazilian economy between 2003 and 2007. The method used to approximate the economic growth model with the observed facts is the same as introduced in the macroeconomic literature by Hansen & Prescott (1991) and

[1] Various articles have used only lump-sum taxes to draw conclusions about the impacts of fiscal policy, among them Edelberg, Eichenbaum & Fisher (1999), Ramey & Shapiro (1998) and Ramey (2010).

popularized by Cole & Ohanian (2004) – analyzing the Great Depression in the United States in the 1930s – and by the volume edited by Kehoe & Prescott (2007), which expands the analysis to 16 cases of crises in various countries in the twentieth century.

The approach follows Conesa, Kehoe & Ruhl (2007), who analyzed the crisis in the 1990s in Finland. This strategy is different than that followed by Burnside, Eichenbaum & Fisher (2004), who analyzed the impacts of changes in fiscal policy by comparing impulse-response functions arising from a neoclassical model of growth with functions estimated for the United States.

This study also provides an explanation for why the observed total factor productivity of the Brazilian economy grew more slowly than output after the reforms at the start of the 1990s. Figure 1 presents real GDP of the population between 10 and 69 years of age and the total factor productivity (the measurement of productivity is discussed in the subsection on growth accounting).[2] It is clear in the figure that productivity growth was greater than output growth during the period. This fact can lead to questions about the returns of the reforms carried out in the early 90s. Or as suggested by Arbache (2004): Why were the reforms unable to increase the standard of living in the Brazilian economy? A possible explanation for output to grow less than productivity would be higher taxation during the period just after the reforms, reducing the standard of living of economic agents.

[2] We use the working-age population to prevent demographic changes from affecting measurement of the evolution of the standard of living (see Kehoe & Prescott, 2007).

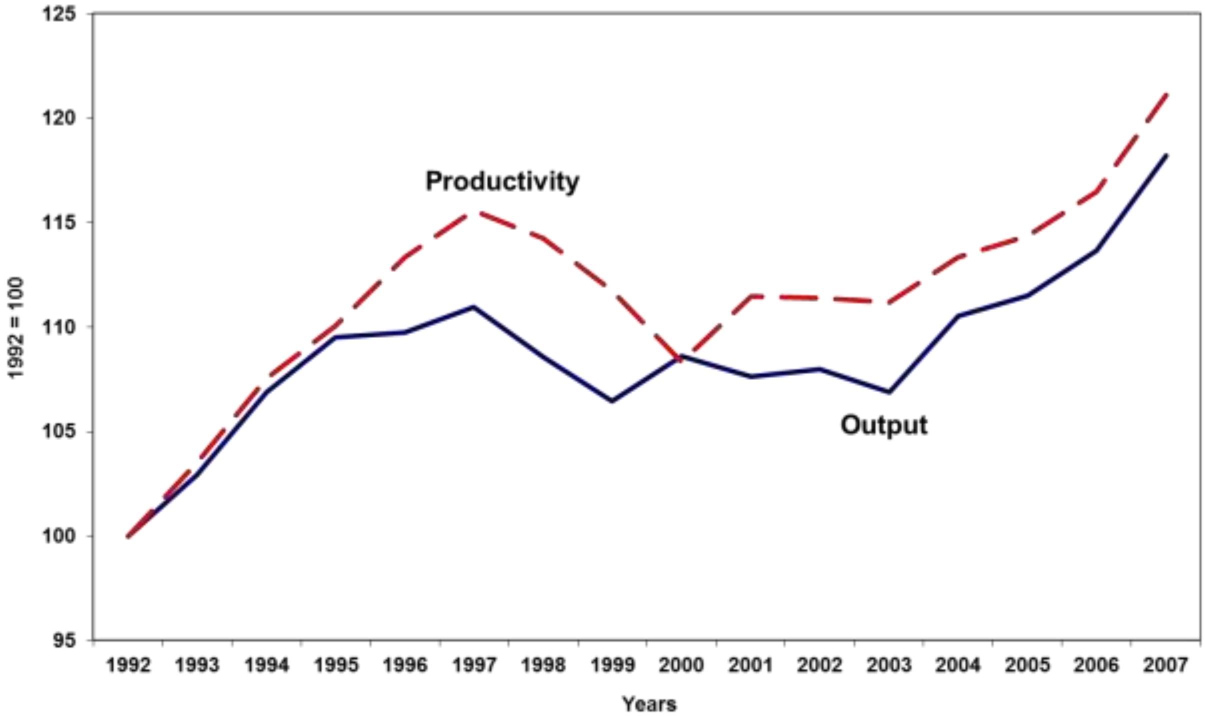

Figure 1 – GDP produced by the population between 10 and 65 years and total factor productivity, 1992-2007

My conclusions are that fiscal policy reduced output growth in the years analyzed. However, the reduction generated by the theoretical model was greater than that observed in the data (especially in relation to the 2003-2007 expansion). The model with taxes and productivity efficiently predicts the behavior of capital, better accounting for the recent trajectory of the economy than the model without taxes. It is noteworthy that the model with taxes predicts a reduction of output while the model without taxes overestimates the observed growth in production in the period analyzed.

In relation to the labor market, both models (with and without distortionary taxes) predict expansion and retraction of hours worked between 1995 and 1999, but the observed data indicate regularity in the number of hours worked by people of working age. For more recent years, the models predict higher growth of the labor supply, due to the tax increases, but the intensity of the growth in hours worked appears stagnant in more recent years.

This article is organized into five sections including this introduction. The next section presents the neoclassical model of growth with and without distortionary taxes. The section on the basic growth model presents a growth accounting exercise for the model in one sector. The third section presents the results of the simulations for the growth model and compares them with the result of the growth accounting exercise, following the method proposed by Kehoe & Prescott (2007) and Hayashi & Prescott (2008). The fourth section presents the estimates of the marginal tax rates on consumption, capital and labor, as well as the results of the simulations for the model with distortionary taxes and productivity. The last section presents the conclusions.

2 NEOCLASSICAL MODEL OF ECONOMIC GROWTH

This section presents the basic economic growth model, with and without taxes, which will be used to evaluate the capacity of the models to account for the observed paths of output and inputs. Specifically, this is a version of the model used in recent articles to analyze deviations from a balanced economic growth path (KEHOE; PRESCOTT, 2007).

The growth model is defined in a closed economy. The utility function of a representative agent is defined on a sequence of consumption $\{C_t\}$ and leisure $\{l_t = \bar{h}N_t - L_t\}$ in which the following problem is solved for each time period t:

$$\left\{\sum_{t=0} \beta^t \left[\alpha \log(C^t) + (1-\alpha)\log(\bar{h}N^t - L^t)\right]\right\}, \quad (1)$$

subject to the budgetary constraint for the period. The budgetary constraint is:

$$C_t + I_t = w_t L_t + r_t K_t, \quad (2)$$

where L_t represents the labor input, α is a parameter affecting the labor-leisure choice, $\bar{h}N_t$ is the total number of hours available for market activities, such that the first term is the number of hours available for labor and the second is the working-age population, β is the intertemporal discount rate, such that $0 < \beta < 1$, w_t is the wage rate, r_t is the rate of remuneration of capital K_t, and I_t represents investment.

The capital stock of this economy obeys the following law of motion:

$$K_{t+1} = (1-\delta)K_t + I_t, \quad (3)$$

where δ is the depreciation rate, $0 < \delta < 1$. Besides this, agents are faced with two other constraints: the first is $C > 0$ and the second is the initial stock of capital, $\bar{K}_{T_0}$.

Firms operate in a market with perfect competition, which can be represented in aggregate form by a Cobb-Douglas production function:

$$Y_t = A_t K_t^{\theta} L_t^{1-\theta}, \quad (4)$$

where Y is the total output of the economy, A is the total factor productivity (TFP) and θ is the participation of the stock of capital in national income, $0 < \theta < 1$. Given that under perfect competition, firms' profits are zero, the prices of the factors are:

$$w_t = (1-\theta) Y_t / L_t \text{ and} \tag{5}$$

$$r_t = \theta Y_t / K_t \ . \tag{6}$$

Then, the output in period t is divided between consumption and investment. The restriction of the economy is thus:

$$C_t + I_t = A_t K_t^{\theta} L_t^{1-\theta} \ . \tag{7}$$

Therefore, given these equations, one can define the equilibrium of this economy.

Definition 1 (Recursive Equilibrium). Given the sequences of productivity, A_t, the working-age population, N_t, $t = T_0$, $T_0 + 1$, ..., and the initial capital stock, $\overline{K}_{T_0}$, an equilibrium is a sequence of wages, w_t, interest rates, r_t, consumption, C_t, labor, L_t, and capital stock, K_t, such that:

(a) given the wages and interest rates, the representative consumer chooses consumption, labor and capital that maximize the utility function (1) subject to the budgetary constraint (2), non-negativity constraints and the restriction on the initial capital stock;

(b) wages and interest rates, together with the choices of firms on labor and capital, satisfy the minimization of costs and the condition of zero profits, equations (5) and (6); and

(c) consumption, labor and capital satisfy the constraint of the economy (7).

2.1 INTRODUCING DISTORTIONARY TAXES

In this section we present the growth model with taxes on the production factors and consumption. The form of introducing these taxes is the standard one in the literature, with taxes on the factors (MCGRATTAN, 1994) and on consumption (as in Prescott, 2002). In the literature on economic cycles, the model with distortionary taxes is what best accounts for the fluctuation of income in the United States (MCGRATTAN, 1994). The model presented here is similar to the models employed by McGrattan (1994), Prescott (2002), Conesa, Kehoe & Ruhl (2007) and Conesa & Kehoe (2007).

Consider an economic environment in which the government uses taxes on production factors and consumption to finance its spending. The representative agent's problem is then to maximize the utility function (1) subject to the new budgetary restriction with taxes:

$$\left(1+\tau_t^c\right)C_t + K_{t+1} = \left(1+\tau_t^1\right)w_t L_t + \left(1+\left(1-\tau_t^k\right)\left(r_t-\delta\right)\right)K_t + T_t \text{ ,} \tag{8}$$

given the constraints of non-negativity and the initial stock of capital. Now, the budgetary constraint contains the taxes τ_t^j such that $j = c, k, l$, for consumption, capital and labor, respectively, and T is a lump-sum transfer of resources received by the government.

The government's budget sequence is:

$$\tau_t^c C_t + \tau_t^1 w_t L_t + \tau_t^k \left(r_t - \delta\right) K_t = G_t + T_t \text{ ,} \tag{9}$$

such that the government finances expenditures, G_t, and makes transfers to individuals of the economy, T_t. Given these two equations, the economy's constraint is altered to:

$$C_t + K_{t+1} - \left(1-\delta\right)K_t + G_t = A_t K_t^{\theta} L_t^{1-\theta}. \tag{10}$$

Given the description of the economic environment, the equilibrium of this economy can be defined.

Definition 2 (Recursive Equilibrium with Taxes). Given the sequences of productivity, A_t, working-age population, N_t, $t = T_0, T_0 + 1, ...$, and the initial capital stock, $\overline{K_{T_0}}$, an equilibrium is a sequence of wages, w_t, interest rates, r_t, consumption, C_t, labor, L_t, and capital stock, K_t, such that:

(a) given the wages and interest rates, the representative consumer chooses consumption, labor and capital to maximize the utility function (1) subject to the budgetary constraint (2), the non-negativity restrictions and constraint on the initial capital stock;

(b) wages and interest rates, together with the choices of firms on labor and capital, satisfy the minimization of costs and the condition of zero profits, equations (5) and (6); and

(c) consumption, labor and capital satisfy the constraint of the economy (7).

2.2 GROWTH ACCOUNTING

In line with the economic growth model, the analysis depends on the procedure known as growth accounting. It is also necessary to define the capital stock and the participation of capital for the economic growth model being used.

Data

To carry out this analysis it is necessary to have data on output, labor and capital. In the case of a closed economy without a government, we assume that investment is equal to gross fixed capital formation and consumption is equal to private consumption, public spending and net exports. In the case with a government, we remove public spending from the consumption model. This strategy is useful, because it permits using GPD for output instead of GNP, when net exports must be considered as investment (HAYASHI; PRECOTT, 2007; BUGARIN et al., 2007).

This model has a single good, implying using the same deflator for all the income components. In this case, we deflate all the series using the deflator of GDP, by which changes in relative prices of capital, increases in the quality of labor and accumulation of human capital are considered to be changes in TFP.

The series used here is the official one, calculated by the Brazilian Institute of Geography and Statistics (IBGE). For more details on the series, see the data in the appendix.

Calibration

We start the model calibration by constructing the capital series. This series is built by using the law of capital motion as in equation (3). An important point is how to choose the depreciation rate of the economy. For the analysis of economic cycles, the most accepted procedure is to determine the depreciation as a function of a steady-state path, as can be described by the law of motion of the capital stock (COOLEY; PRESCOTT, 1995):

$$\delta = \frac{I}{K} + 1 - (1+\gamma)(1+\eta), \tag{11}$$

where γ is the growth rate of TFP, η is the growth rate of the working-age population (between 10-69 years), and I/K is the mean investment-capital ratio. This method is very useful to analyze an economy in its steady state path, but tends to overestimate the depreciation when the economy deviates from the balanced growth path. Therefore, so as not to overestimate the depreciation, we chose its value as 5% a year.

TFP can be defined from the production function (4) as:

$$A_t = \frac{Y_t}{K_t^{\theta} L_t^{1-\theta}} . \tag{12}$$

To compute TFP (A), it is necessary to calibrate the participation of capital, θ. To calibrate this result, we use the evidence from Gomes, Bugarin & Ellery (2005) and calibrate this value at 0.35.

Historic Growth

Using the series on output, capital and labor, one can calculate TFP and carry out the growth accounting procedure. In this case we use a decomposition suggested by Hayashi & Prescott (2007). Our starting point is the production function as presented in equation (4). Taking the natural logarithm in the production function and rearranging the terms yields the following equation:

$$\ln\left(\frac{Y_t}{N_t}\right) = \frac{1}{1-\theta}\ln A_t + \frac{\theta}{1-\theta}\ln\left(\frac{K_t}{Y_t}\right) + \ln\left(\frac{L_t}{N_t}\right). \tag{13}$$

From equation (13), the change in real per capital GPD between period t and $t + s$ can be obtained as:

$$\begin{aligned}\left[\ln\left(\frac{Y_{t+s}}{N_{t+s}}\right) - \ln\left(\frac{Y_t}{N_t}\right)\right]/s &= \frac{1}{1-\theta}\left[\ln A_{t+s} - \ln A_t\right]/s \\ &+ \frac{\theta}{1-\theta}\left[\ln\left(\frac{K_{t+s}}{Y_{t+s}}\right) - \ln\left(\frac{K_t}{Y_t}\right)\right]/s + \left[\ln\left(\frac{L_{t+s}}{N_{t+s}}\right) - \ln\left(\frac{L_t}{N_t}\right)\right]/s\end{aligned} \tag{14}$$

where the right-hand terms are the contributions to growth due to TFP, capital intensity and labor intensity, respectively. In the balanced growth path, the second and third terms are equal to zero, since the capital-output ratio and the total hours worked per working-age person are constant. Therefore, all growth must be a function of productivity alone in the balanced growth path.

Table 1 and Figure 2 present the growth accounting for the single-good model, where investment is deflated by the GDP deflator. Table 1 shows the growth accounting for the entire period, 1995 to 2007, and sub-periods, chosen according to the breaks in the output series, as observed in Figure 1. These breaks occurred in: (i) 1997, when output reverted to the trend and started to decline; and (ii) 2003, when output started to grow again.[3] These features of productivity in the period analyzed are also reported in Barbosa Filho, Pessoa & Veloso (2010).

Analysis of the results for these 12 years in Brazil clearly shows that productivity grew faster than output, indicating the economy could have grown more. Both in the period of expansion and that of retraction, productivity growth outpaced growth of output per person. This type of trajectory is compatible with the idea of Cole & Ohanian (2004) that factors inhibiting competitiveness can keep the economy below the growth level permitted by productivity alone.

Table 1 – Accounting for Growth, One-Sector Model

Periods	*Y/N*	*TFP*	*K/Y*	*L/N*
1995-2007	0.64	1.22	-0.51	-0.08
1995-2003	-0.30	0.20	-0.01	-0.49
2003-2007	2.52	3.28	-1.50	0.75

Another characteristic indicated in the series is the reduction of labor intensity (L/N) during the period analyzed, without showing and signs of recovery of intensity. There is no theoretical need for an increase in labor intensity, but the reduction of this intensity can cause output to take a lower path than that possibly predicted by productivity.

In relation to capital intensity (K/Y), the economic growth model predicts that it is constant on the balanced growth path (definition 1). Therefore, changes in K/Y in general are associated with cyclical changes in productivity, as is clear in the large output shock in 2004, when K/Y fell and productivity rose. Another observation is the modest increase in the capital-output ratio between 1997 and 2003. Analysis of Figure 2 leads to the question of what caused the change in productivity that began between 2003 and 2004.

[3] We start our analysis of the Brazilian economy in 1995 because this marked the start of the new National Accounts series computed by the IBGE. Since there are no deflators to connect this series with earlier periods (which were marked by high inflation, at times hyperinflation, interspersed with brief periods of stability after ultimately unsuccessful stabilization programs), we concentrate on analyzing the economy between 1995 and 2007.

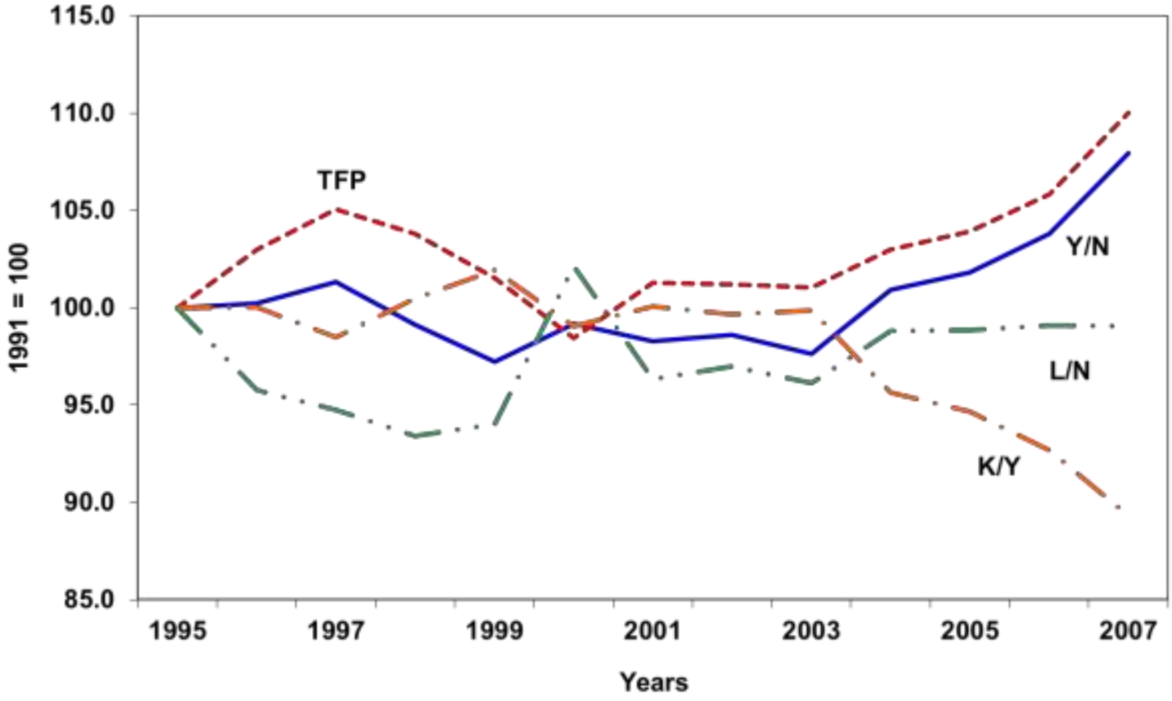

Figure 2 – Accounting for Growth, One-Sector Model

3 SIMULATION: MODEL WITHOUT TAXES

To simulate the dynamic general equilibrium model, we use the series on productivity and population as inputs. Besides this, it is necessary to calibrate the parameters β and α, as well as the parameters already defined, θ and δ.

To calibrate the intertemporal discount rate, β, we use the first-order condition of the dynamic general equilibrium model, which implies that:

$$\beta = \frac{1+\gamma}{\theta(Y/K)-\delta+1}. \tag{15}$$

Using this equation, we calibrate β as 0.94. This number is found given the average of *Y*/*K*, equal to 0.40, and the other parameters used previously (COOLEY; PRESCOTT, 1995). Since we are simulating the economy in its balanced growth path, we calibrate the intertemporal discount rate for the period from 1995 to 2007.

The procedure to calibrate α is similar. Using the first-order condition associated with the labor-leisure choice, we can write:

$$\alpha = \frac{C_t L_t}{Y_t\left(hN_t - L_t\right)\left(1-\theta\right)+C_t L_t}. \tag{16}$$

Using data on hours worked, consumption, output, labor endowment of the economy and capital participation in national income, we calibrate $\alpha = 0.25$ for the 1995-2007 period.

Next we present the results of the numerical experiments. Figure 3 presents the GPD produced by the working-age population (10-69 years) with removal of the technology frontier trend. Table 2 compares the growth accounting for the real economy with the figure for the artificial economy. The result of the dynamic general equilibrium model predicts a higher increase in output than actually occurred. This increase is due to the fact that productivity growth outpaced output growth in the economic data (see Figure 2). Productivity growth between 1992 and 1997 was greater than GDP growth, at 3.47% versus 1.36%, while between 1997 and 2003 productivity declined more than output (– 1.05% against – 0.94%). Another period with high productivity growth was 2003 and 2004. Finally, particularly between 1995 and 1997 the prediction is for strong economic growth, while the observed series showed a reduction in output per person.

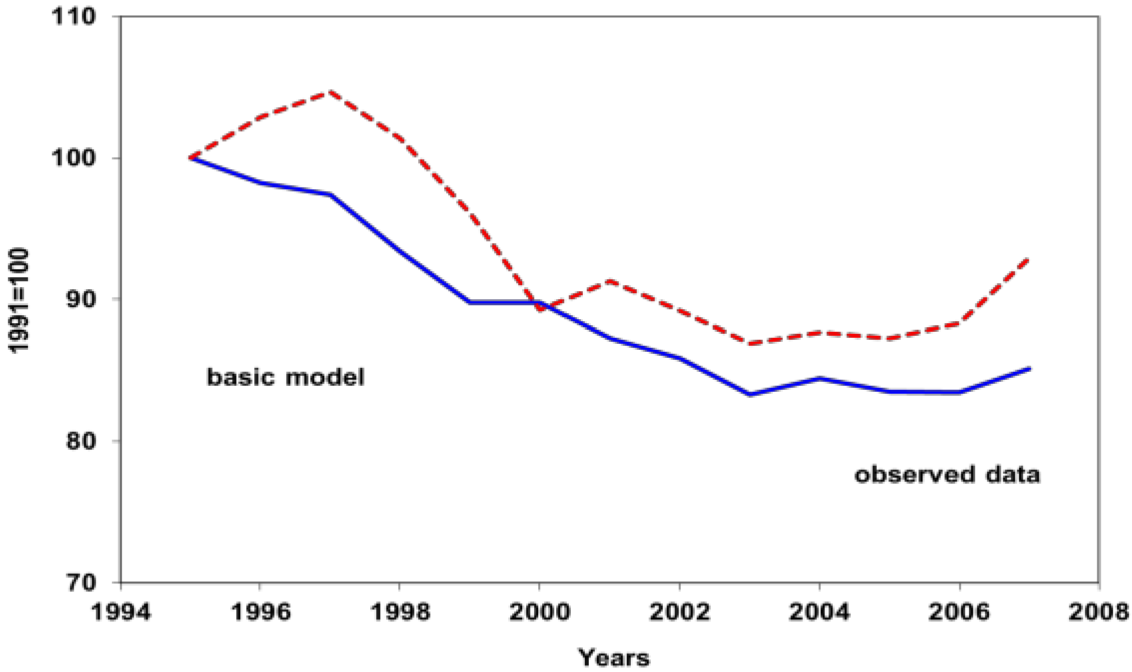

Figure 3 – Detrended Output: Observed and Simulated Data

Table 2 – Simulation Model without Taxes

Period	*Y/N*	*TFP*	*K/Y*	*L/N*
Actual Data				
1995-2007	0.64	1.22	-0.51	-0.08
1995-2003	-0.30	0.20	-0.01	-0.49
2003-2007	2.52	3.28	-1.50	0.75
Basic Model				
1995-2007	1.37	1.22	-0.42	0.56
1995-2003	0.23	0.20	0.16	-0.13
2003-2006	3.65	3.28	-1.56	1.94

Figure 4 shows the capital-output ratio from the simulated model versus the actual figures. It can be seen that the simulated model well replicates the behavior of the capital-output ratio. In turn, Figure 5 shows the ratio of total hours worked over total time endowment per person (including leisure). The simulation of the labor market is one point where the basic model fails to reproduce the real results. While the actual series fell, the model predicts an increase in labor intensity. This result is the same found by Bugarin et al. (2007) and it is exactly this point that will be examined when introducing taxes in the basic growth model.

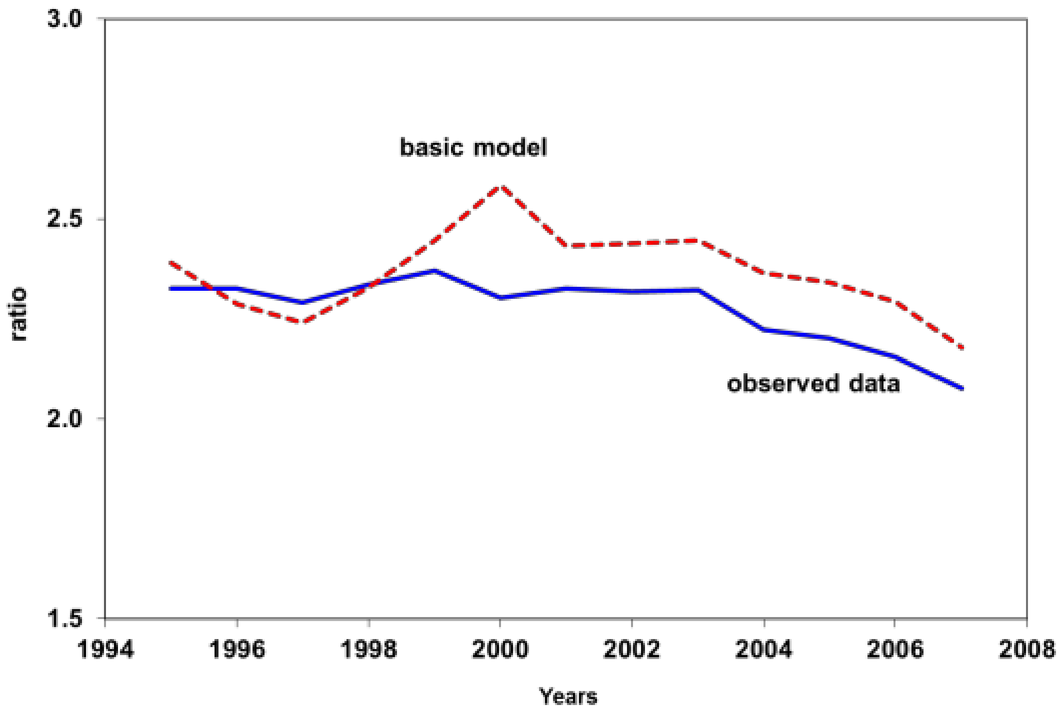

Figure 4 – Capital-Output Ratio: Observed and Simulated Data

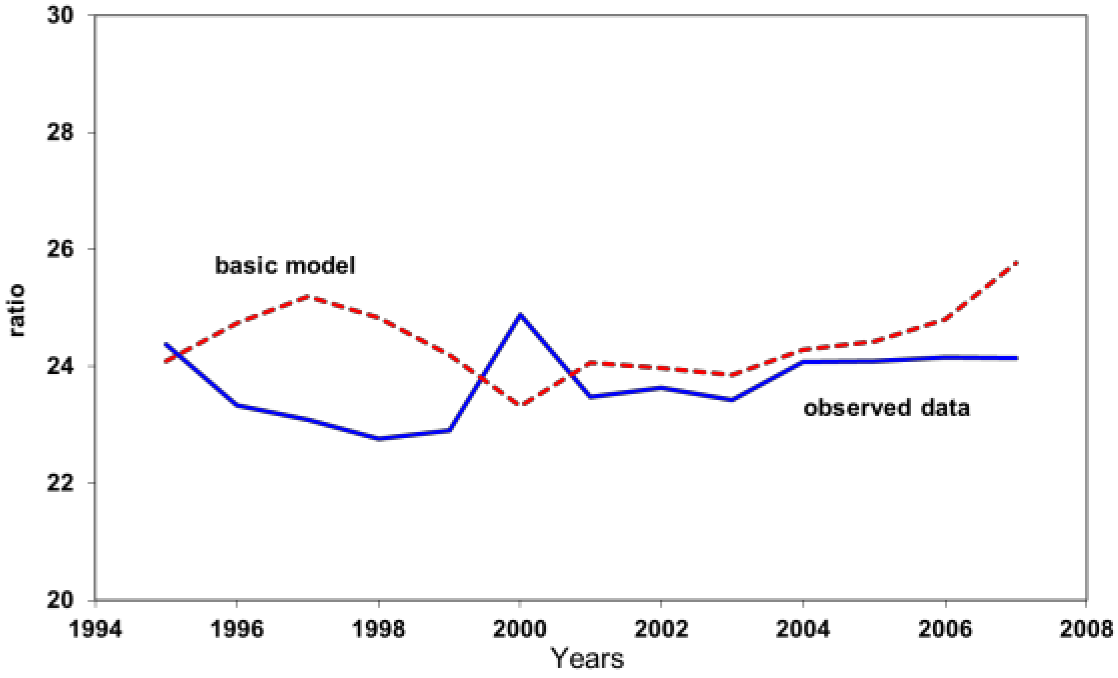

Figure 5 – Labor Market: Observed and Simulated Data

4 SIMULATION: MODEL WITH DISTORTIONARY TAXES

The Brazilian economy over the period from 1991 to 2007 was marked by an increase in the share of public spending and taxes in the economy.

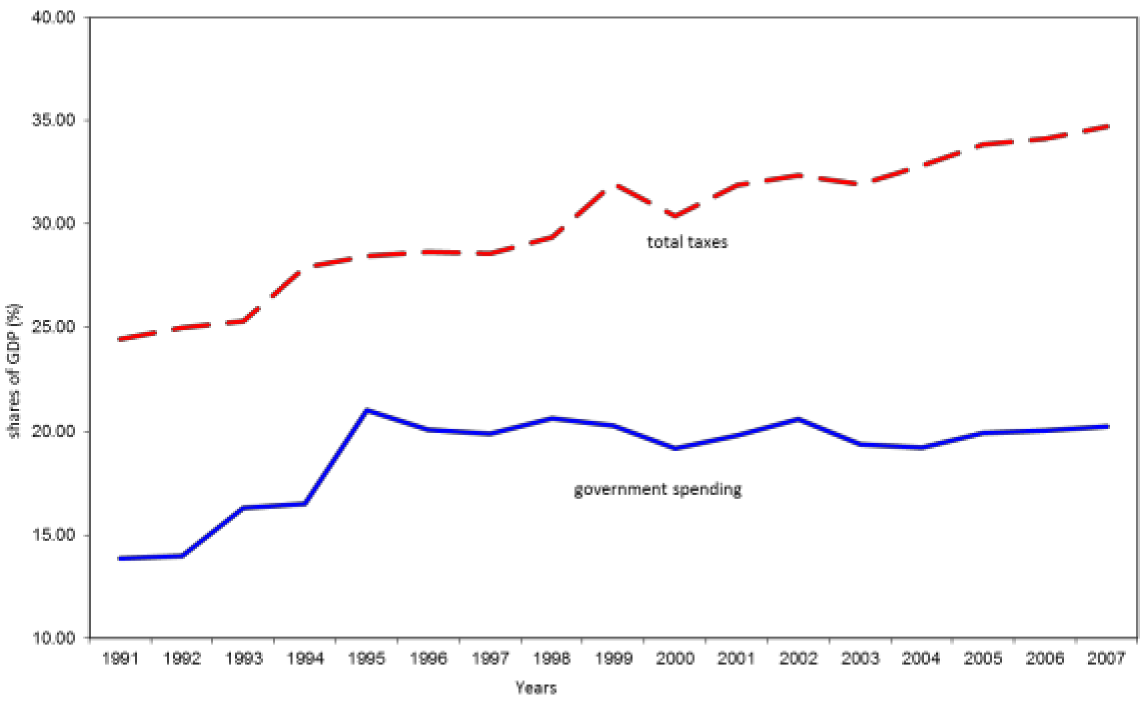

Figure 6 – Public Spending and Taxes: Share of GDP, 1991-2007

To simulate the model with distortionary taxes it is necessary to use the simulation of the series of marginal tax rates on consumption, labor and capital as inputs, along with the series on productivity and working-age population (10-69 years). In the economic literature it is common to find calculations of average effective tax rates (MENDOZA; RAZIM; TESAR, 1994), but since the relevant decisions of the model are taken at the margin, it is necessary to use marginal tax rates.

To calculate the marginal rates it is first necessary to compute the effective rates. For this purpose, we follow the methods of Joines (1981) and Mendoza, Razim & Tesar (1994). Araújo Neto & Sousa (2003) applied the method of Mendoza, Razim & Tesar (1994) to Brazilian data covering 1975 to 1999. However, the authors argued that various observations of data from the National Accounts could not be collected and some (smaller) taxes were not used to compute the effective rates.

Effective tax rate on consumption

To calculate the effective tax rate on consumption, we added the revenue from general taxes on goods and services and the revenue from exceptional taxes on consumption (such as special taxes on beverages and fuels). Then we calculated the ratio of this revenue from consumption taxes over the pretax value of consumption less revenue from indirect taxes (it should be noted that in the case of consumption, the marginal rate is equal to the average rate), i.e.:

$$\tau_t^c = \frac{R_{goods,t} + R_{ex,t}}{C_t + G_t - (R_{goods,t} + R_{ex,t})}, \quad (17)$$

where R_{goods} denotes the general revenue from taxes on goods and services and R_{ex} is the revenue from exceptional taxes. In the case of the model for a closed economy with government, the total consumption of the economy is household consumption plus net exports. Therefore, the total consumption of the economy with a government is represented by $C + G$.

Taxes on the factors

The total tax rate on the representative agent is the ratio of revenue from income tax on the individual – which is the difference between the individual's pretax and after-tax income – over pretax income. The latter is defined as the sum of wages and non-wage income (i.e., the sum of the compensation for labor, rental income, business income and the gross operating excess of unincorporated businesses). The method used here follows two steps. First we compute the aggregate marginal tax rate on the individual's income, and then the effective rates on labor and capital.

The aggregate marginal rate on the individual's income, $\tau^h{}_t$, is:

$$\tau_t^h = \mu \frac{R_{inc,t}}{CE_t + M_t - SSE_t} , \tag{18}$$

where R_{inc} is the revenue from taxes on income, profits and capital gains, CE is the compensation for labor received, M is the gross operating excess received, and SSE is the social security contribution of employers. The term μ is an adjustment factor that transforms the average rate into a marginal rate, because when $\mu = 1$, the average rate tends to be lower than the marginal rate, since because taxes are progressive, they tend to have a greater impact on the agent's decision. Therefore, following Prescott (2002), we use $\mu = 1.6$.

To calculate the marginal rates on labor and capital, it is necessary to determine the income categories for labor and capital. Basically the problem is in the gross operating excess, because part of this income is due to labor and part to capital. Following Gollin (2002) and Conesa, Kehoe & Ruhl (2007), we assume that the income received by capital is proportional to that received by the production factors, i.e., proportional to the share of capital in national income (θ).

Then, we compute the effective tax rate on labor as:

$$\tau_t^l = \frac{\tau_t^h\left(CE_t - SSE_t + (1-\theta)M_t\right) + R_{soc,t} + R_{pay,t}}{(1-\theta)(Y_t - T_t)} , \tag{19}$$

where R_{soc} is the total social security contributions, R_{pay} is taxes on payroll and other labor income, and T is the total taxes minus subsidies, as appears in the National Accounts System.

To compute the marginal tax rate on capital, we use:

$$\tau_t^k = \frac{\tau_t^h\left(\theta M_t\right) + R_{corp,t} + R_{prop,t}}{\theta(Y_t - T_t)} , \tag{20}$$

where R_{corp} is the total corporate tax rate (taxes on income, profits and capital gains), and R_{prop} is taxes on real estate and other fixed assets. This formula represents the difference between the pretax and after-tax income from capital over the pretax income from capital.

Figure 7 presents the marginal rates of taxes on consumption, labor income and capital. Due to the unavailability of data, we only could calculate the marginal rates for the period from 1991 to 2007. The result clearly shows the increasing tax rates, the largest being on income from capital, which rose from about 10% to 27%. But the other two rates also increased, with the tax on consumption increasing the least.

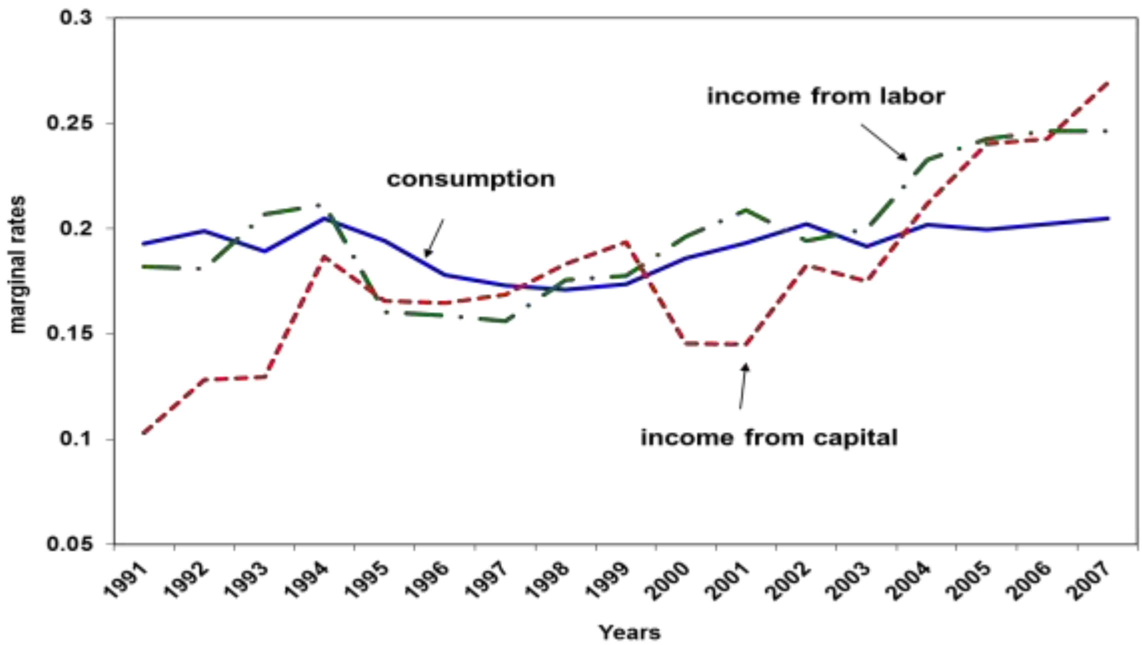

Figure 7 - Marginal tax rate on consumption and income from the factors, 1991-2007

When introducing taxes, the natural expectation is for them to cause distortions in the relative prices in the economy. However, to simulate the model with taxes it is necessary to recalibrate the parameters β and α, because the presence of distortionary taxes affects the first-order conditions of the dynamic general equilibrium model. For this purpose, we used $\beta = 0.97$ and $\alpha = 0.35$.

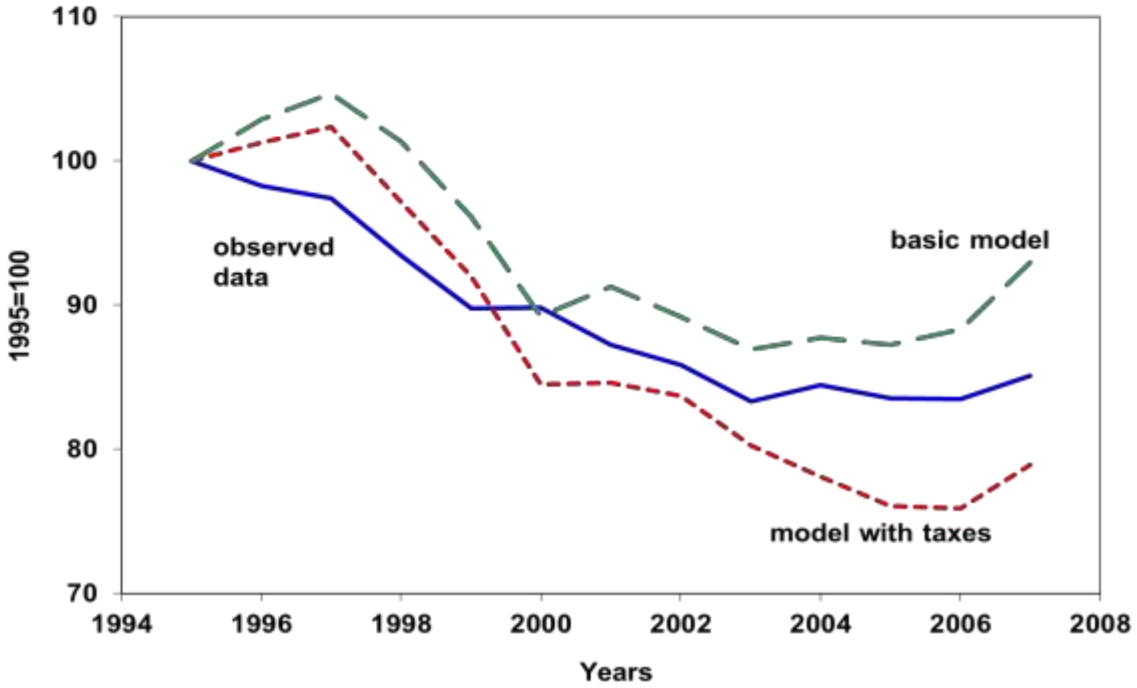

Figure 8 – Detrended Output per Person (10-69 years): Simulations

Figures 8 to 10 present the results of the simulations for the dynamic general equilibrium model with taxes together with the results of the model without taxes, as well as the observed data for the Brazilian economy in the period from 1995 to 2007. Table 3 reports the observed growth of the economy and the predictions of the model with and without taxes. Comparison of the simulated output results against the observed figure shows the high capacity to replicate the output path starting in 1999. This suggests that the model with distortions on relative prices and TFP is sufficient to explain the recent behavior of the Brazilian economy. Another conclusion that can be drawn from comparing the basic model and the observed data is that the level of income could have been approximately 20% higher in 2006 if the marginal tax rates had remained constant in this period.

Table 3 – Model with and without Taxes

Economic Periods	*Y/N*	*TFP*	*K/Y*	*L/N*
Observed				
1995-2007	0.64	1.22	-0.51	-0.08
1995-2003	-0.30	0.20	-0.01	-0.49
2003-2007	2.52	3.28	-1.50	0.75

Basic Model

1995-2007	1.37	1.22	-0.42	0.56
1995-2003	0.23	0.20	0.16	-0.13
2003-2006	3.65	3.28	-1.56	1.94

Model with Taxes

1995-2007	0.01	1.22	-0.81	-0.41
1995-2003	-0.77	0.20	-0.27	-0.75
2003-2006	1.56	3.28	-1.90	0.28

As mentioned before, Bugarin et al. (2007) showed that an important point in applying dynamic general equilibrium models to Brazil is the failure to account for the behavior of the labor market since 1988. Here we expanded the series to 2006 and introduced taxes on consumption and labor income, which directly affect households' decisions on supply of labor.[4] The model with taxes closely reproduces the behavior of the labor market between 1999 and 2003. In contrast, in the period from 1995 to 1998, the model predicts a large increase in hours worked due to the large increase in productivity, but this expansion did not happen in the real economy.

[4] Here we use observations from 1991 to 2006 while Bugarin et al. (2007) used data from 1980 to 1998. But the simulated and real data match between 1991 and 1994.

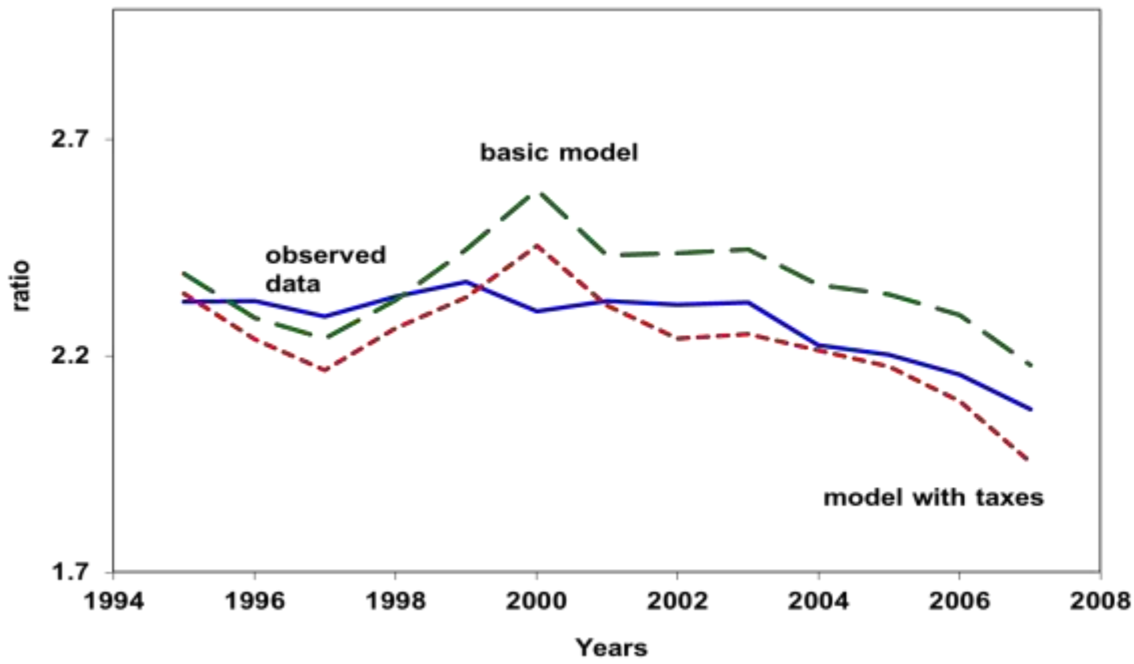

Figure 9 – Capital-Output Ratio: Simulations

Figure 9 shows there is a good approximation between the true and artificial capital-output ratio. The simulated series for both cases is more volatile than the observed data, basically because TFP is highly volatile.

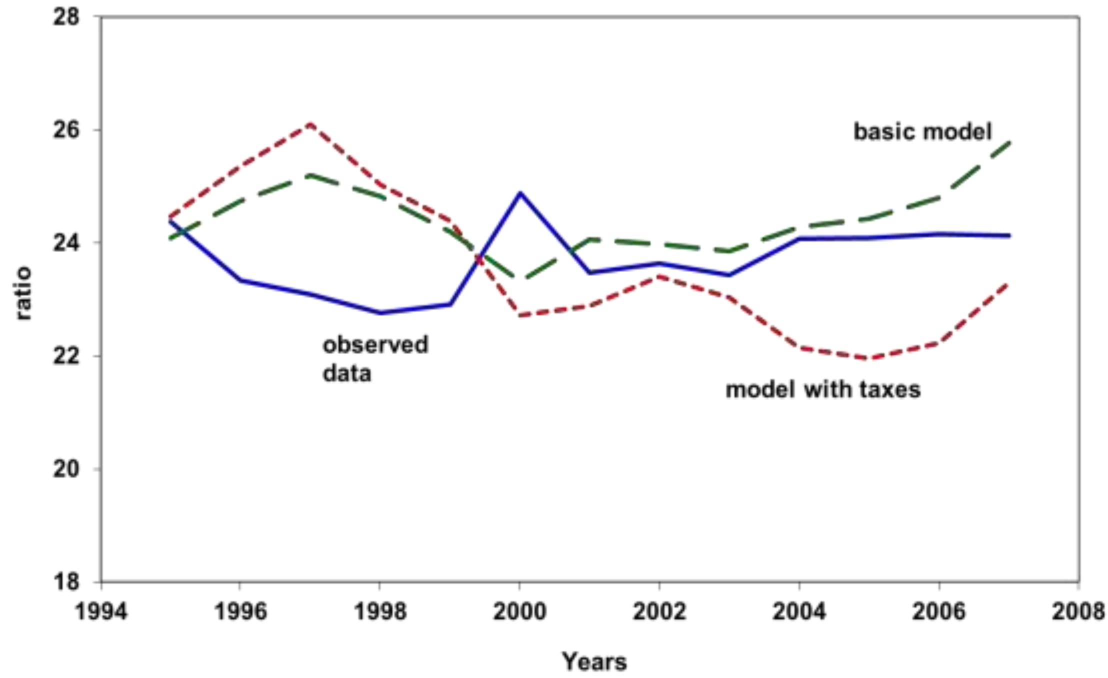

Figure 10 – Labor Market: Simulations

In the case of the behavior of consumption, the growth model with taxes matches best with the observed series, but the model once again does not capture the behavior during the period from 1995 and 1998. The behavior of consumption is the same as that for the output and labor series.

5 FINAL CONSIDERATIONS

The objective of this study was to assess the impact of taxes on output, capital and labor of the Brazilian economy by using the neoclassical growth model expanded with the introduction of distortionary taxes.

The results show that the increase in marginal tax rates can be an explanation for the low growth after the reforms in the 1990s, as suggested by Arbache (2004). The results also indicate that the recent growth path is well described by productivity. However, using only productivity in the simulations caused output growth to be greater than that observed in the Brazilian economy. The introduction of distortionary taxes was able to reduce the output level of the artificial economy, but it led to underestimation of the output level.

Finally, the simulated models failed to predict the behavior of the labor market. Both only managed to reproduce this behavior well during short periods. This failing can indicate the existence of a labor wedge, as defined by Chari, Kehoe & McGrattan (2007). This leads to the assumption that models with nominal rigidity or with cartelization can be more suitable to understand the recent behavior of the Brazilian economy.

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APPENDIX

Table A.1 – Participation of Public Expenditures and Taxes in GDP and Marginal Rates (%)

Years	*G/Y*	*T/Y*	τ^c	τ^l	τ^k
1991	13.87	24.43	19.29	18.22	10.32
1992	13.97	24.96	19.91	18.12	12.84
1993	16.29	25.3	18.92	20.68	12.95
1994	16.51	27.9	20.49	21.17	18.67
1995	21.04	28.44	19.44	16.04	16.59
1996	20.10	28.63	17.80	15.89	16.49
1997	19.90	28.58	17.30	15.62	16.87
1998	20.64	29.33	17.12	17.58	18.32
1999	20.30	31.97	17.39	17.76	19.36
2000	19.17	30.36	18.59	19.64	14.56
2001	19.82	31.87	19.34	20.89	14.54
2002	20.58	32.35	20.22	19.44	18.26
2003	19.39	31.9	19.15	19.99	17.51
2004	19.23	32.82	20.20	23.29	21.20
2005	19.91	33.83	19.96	24.28	24.04
2006	20.03	34.12	20.24	24.62	24.27
2007	20.26	34.71	20.48	24.62	26.92