

# The Brazilian Depression in the 1980s and 1990s<sup>N</sup>

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## Abstract

After being one of the fastest growing countries from the end of World War II to the beginning of the 80s, the Brazilian GNP per working-age person dropped 30% below trend during the 80s and 90s. The present study investigates how much of this performance can be explained by the neoclassical growth model. We found that the basic growth model, with exogenous productivity shocks, can account for the actual decline in the Brazilian real GNP and consumption per working-age person for the period 1981-1998. Once we correct for changes in the relative prices of investment goods, the model can also account for the behavior of investment and capital stock. However, the model does not perform well with respect to the series of hours worked. We suggest that the implemented changes in the tax system and the mandatory reduction in the workweek in the end of 1980s and beginning of the 1990s could account for this discrepancy between the model and the data.

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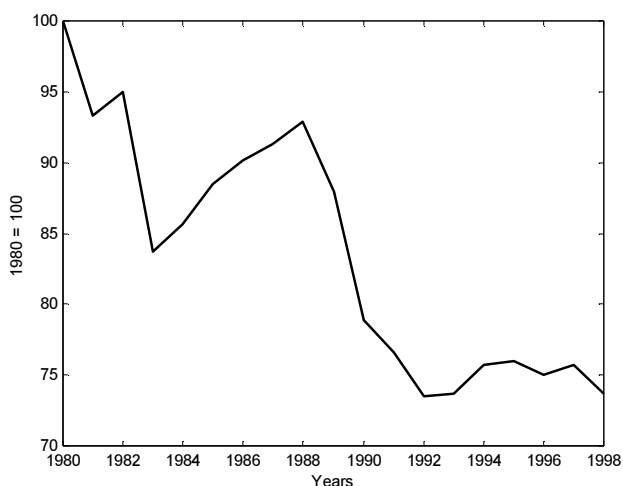
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## 1. Introduction

The Brazilian economy experienced two distinct periods after World War II. During the first period, 1957-1979, Brazil was one of the fastest growing countries. In the second period, after 1980, the Brazilian output experienced a large drop. Figure 1 shows that the output per working age (10-69)<sup>1</sup> person is more than 25% below trend.

Brazil is in a depression. Kehoe and Prescott (2002, pp. 8-10) define a depression as a large and persistent deviation of aggregate output per working age person from its trend, such that it falls at least 15% within the first decade and remains at least 20% below trend. The Brazilian GNP per working-age person dropped by more than 15% below trend during the 1980s and remained 25% below trend in the 1990s (see Figure 1).

**Figure 1 – Detrended GNP per Working age Person, Brazil (1980-1998)**



In this paper, we study the Brazilian depression using a general equilibrium growth model. We follow the line of research begun by Cole and Ohanian's (1999) analysis of the Great Depression in the United States. Many authors have shown variants of the general equilibrium growth model to be useful for studying depressions, from those of the interwar period in Europe and North America to those

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<sup>1</sup> We assume 10-69 years instead of 15-65, because we do not have such data.

experienced recently in Japan and Latin America.<sup>2</sup> Bergoeing, Kehoe, Kehoe, and Soto (2002a and 2002b) examine the depression of the Chilean and Mexican economies in the 1980s and 1990s. Kydland and Zarazaga (2002) analyze the Argentinean decline in economic activity during 1974-1990.

We show that the growth model can replicate Brazil's contraction in the 1980s and the 1990s. The standard growth model generates the actual behavior of output, consumption and investment. It is unable to replicate the behavior of hours worked and capital stock.

However, once the data were corrected for significant distortions of the relative price of investment observed in Brazil, there is significant improvement of the model's ability to generate the observed dynamics of capital and investment.

The model economy fails to replicate the dynamics of hours worked, in particular after 1990. We argue that institutional changes introduced by the Brazilian Constitutional reform in 1988, especially limits on weekly work hours, help explain the results.

The rest of the paper is divided as follows. Section 2 briefly presents the main empirical evidence of Brazil's "lost decade(s)" of the 1980s and the 1990s. Section 3 describes the growth accounting exercise. Section 4 introduces the standard growth model used for the numerical experiments, the description of the calibration procedure, and the numerical experiment. In Section 5 we discuss some remarks on the interpretation of the obtained results as well some possible ways to solve the problems found in the numerical simulation of the standard model. Section 6 concludes by discussing the implications of the results for future research.

## **2. The empirical facts**

Among other Latin American countries, Argentina, Mexico and Chile experienced deep depressions during the 1980s. Argentinean GNP per working age person dropped 37% below trend in 1990 according to Kydland and Zarazaga (2002). Chile's output per worker fell approximately 20% below trend in 1983 and Mexico's fell about 40% below trend in 1993 (Bergoeing, Kehoe, Kehoe, and Soto, 2002a).

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<sup>2</sup> For example, see the papers in January 2002 issue of the *Review of Economic Dynamics* and the May 2002 issue of the *American Economic Review*.

In terms of its persistence, the Brazilian depression is similar to those experienced by Mexico and Argentina in the 1980s and 1990s and by New Zealand during the period 1974-1992.<sup>3</sup> Like these Latin American countries, the Brazilian contraction lasted at least 10 years or more than twice as the U.S. Great Depression.

According to the definition we use, Brazil's is not a deep depression when compared with other countries.<sup>4</sup> For instance, Cole and Ohanian (1999) report that U.S. per working age aggregate output went down 38.3% below trend in 1933. Amaral and MacGee (2002) show a deviation of 40.4% below trend for Canada in 1933. For European countries such as Germany and France, per capita GNP fell about 32% (in 1932) and 33% (in 1939) below trend respectively, according to Fisher and Hornstein (2002) and Beaudry and Portier (2002).

### **2.1. Brazilian Aggregate Output and its Components**

In this section, we analyze Brazil's national account data.<sup>5</sup> Since we aim to understand the deviations from trend of the main aggregate series, all data have been detrended. Table 1 presents the detrended indexes of output per working age person and its components. Numbers in bold are the lowest level for each series during the period 1990-1998.

The above empirical evidence shows a sharp decline in the Brazilian GNP per working age person. In 1992, twelve years after the beginning of the contraction, the GNP per working age person was 26.5% below trend. There are two sub-periods when the economy shows some signs of recovery: during 1985-1988 and, much more timidly, from 1993 to 1997. However, these recoveries were not able to bring the economy back to trend. At the end of the 1990s, the Brazilian economy was still 26.4% below trend.

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<sup>3</sup> For this case refer to Kehoe and Prescott (2002).

<sup>4</sup> The Brazilian experience shows that GNP per working age person has a trend of approximately 2.55%, implied by a growth rate of total factor productivity (TFP) of 1.6% for the period 1950-1979. Although this trend appears to be much higher than the one corresponding to other Latin American countries as Argentina, Chile and Mexico, it is consistent with the fact that Brazil was the Latin American growth leader from the 1950s up to the 1970s. For example, the Brazilian income grew at rates significantly higher than the U.S. during the period 1952-1980, from approximately 15% of US per capita GDP reaching almost 32% in 1980. This shows a convergence path for the Brazilian economy until 1980. This implies that the depression in Brazil is bigger when is considered the convergence path of the economy, i.e. when using the 2.55% instead of 2.00%. For example, for the 2.55% trend the depression in 1998 reach a trend deviation of 66.87%, while for 2% trend the figure is 73.67%.

<sup>5</sup> See the appendix for more detail about the Brazilian data.

All components remain below trend except for government consumption, which increased more than 35% above trend, from 1981 to 1998. The imports fall more than 60% below trend from 1980 to 1989 and remained about 35% below trend in the 1990s. The exports index drop 43% below trend in 1996.

**Table 1 – Detrended Per Working Age Person Output and Components, 1981-1998 (1980 = 100)**

Years	Consumption						Foreign trade		
	GNP	Nondur.	Durables	Total Invest.	Private Invest.	Gov't Invest.	Gov't Consump.	Imports	Exports
1981	93.3	93.6	82.7	88,8	91.7	102.9	95.0	81.3	97.6
1982	95.0	96.7	97.5	88,3	86.4	95.3	104.5	70.3	80.7
1983	83.6	89.0	83.3	63,4	60.3	65.5	89.1	67.6	107.0
1984	85.7	87.8	98.1	66,6	56.5	69.2	77.7	60.5	129.1
1985	88.4	84.6	90.5	84,1	72.9	86.7	95.0	55.5	119.6
1986	90.1	86.5	100.2	82,1	70.6	117.3	104.7	50.7	87.8
1987	91.3	81.7	84.5	84,9	82.9	120.8	122.7	48.8	93.0
1988	92.8	83.3	73.7	81,9	83.9	117.4	123.2	44.3	105.8
1989	87.9	73.1	69.1	84,8	91.9	108.9	136.8	39.2	80.1
1990	78.9	64.2	65.2	64,5	62.6	107.8	136.1	48.3	64.0
1991	76.5	67.1	53.9	63,3	60.2	92.4	114.4	53.2	71.0
1992	73.5	65.2	50.1	56,1	53.0	106.2	110.3	53.9	80.9
1993	73.7	66.1	50.6	63,2	61.5	99.5	129.8	59.0	79.1
1994	75.7	70.0	59.0	68,2	64.3	113.8	134.0	60.5	71.0
1995	75.9	70.3	63.7	69,8	67.1	80.1	139.0	62.8	59.2
1996	75.0	67.2	59.7	66,8	65.6	72.0	148.4	58.1	57.0
1997	75.7	68.4	59.7	69,1	69.0	69.7	144.2	65.4	62.2
1998	73.6	67.9	52.6	63,6	65.5	67.4	139.2	62.4	58.8

Note: All variables are detrended by 2% growth rate of output per working age person.. See the data appendix for details on these series. Nondur. is the consumption of non-durables.

Table 2 shows aggregate consumption, investment, government expenditures, exports and imports as a share of GDP for the period 1980-1998. Aggregate consumption drops from 59% in 1980 to 50% in 1990 and still in 1998 does not recover to the 1980's share. Investment, on the other side, starts with a 34% share in 1980, it falls to 27% in the initial years of depression, and returned to the same level of 1980 in 1989. In the next eight years, investment drops to 27% in 1992, the same figure of 83 and 84, and then rises to about 30% of output in 1995-1998 period. This modest drop in the investment share led to the rise of the capital stock in the subsequent time period (see Table 3).<sup>6</sup> It is noteworthy that government's expenditure

<sup>6</sup> For understand the behavior of investment share we can compare with the US Great Depression. As reported by Cole and Ohanian (1999, Table 3), the investment share drop from 25% of output in 1929

share in aggregate output steadily increases from 1980 to 1998. Imports and exports do not show a clear pattern and remain in 1998 at about the same level as in 1980. In the case of exports, this component of output rose in the first years of the depression but return to the 1980 level in 1986.

**Table 2 – Composition of output (as shares of GDP), 1980-1998**

Years	Consumption	Investment	Gov't cons.	Imports	Exports
1980	0,59	0,34	0,09	0,11	0,09
1981	0,59	0,32	0,09	0,10	0,09
1982	0,59	0,32	0,10	0,08	0,08
1983	0,61	0,27	0,10	0,09	0,11
1984	0,59	0,27	0,08	0,08	0,13
1985	0,55	0,30	0,10	0,07	0,12
1986	0,56	0,31	0,11	0,06	0,09
1987	0,53	0,32	0,12	0,06	0,09
1988	0,53	0,30	0,12	0,05	0,10
1989	0,51	0,34	0,15	0,05	0,09
1990	0,50	0,30	0,16	0,07	0,08
1991	0,54	0,28	0,14	0,08	0,09
1992	0,54	0,27	0,14	0,09	0,10
1993	0,53	0,28	0,16	0,09	0,10
1994	0,54	0,29	0,16	0,09	0,08
1995	0,55	0,30	0,17	0,09	0,07
1996	0,54	0,30	0,18	0,09	0,07
1997	0,55	0,30	0,18	0,10	0,08
1998	0,56	0,29	0,18	0,10	0,07

Note: Consumption here is the consumption of non-durables. Investment is adds the consumption of durables and inventories. Gov't cons. is the government consumption in goods and services. All variables are shares of GDP at 1998 prices.

Table 3 presents detrended aggregate output (GNP) and inputs (per working age person), the capital output ratio (K/Y), the productivity of hours worked (Y/H) and the percentage of industrial capacity utilization. During the three first years of the contraction, hours worked and capital do not fall below trend, unlike GNP. The latter falls as much as 36.5% below trend in 1992 and remains more than 20% below trend from then on.

**Table 3 – Aggregate Output and Inputs  
(Index, 1980 = 100)**

Years	GNP	Capital	K/Y	Hours	Average	Y/H	Industrial
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to 8% in 1932. This figure represents a drop of 68% of investment share. In the first years of Brazilian crises the investment share drops 21%, than we can state that the drop of investment share was modest in the Brazilian depression.

	weekly hours						capacity utilization (%)
1980	100,0	100,0	<b>1,98</b>	100,0	100,0	100,00	84,0
1981	93,3	105,7	2,24	104,2	99,3	89,51	78,0
1982	95,0	108,1	2,25	107,2	99,2	88,60	76,0
1983	83,6	109,8	2,60	105,2	98,6	79,53	73,0
1984	85,7	108,3	2,50	107,0	99,2	80,05	74,0
1985	88,4	108,3	2,42	111,7	99,1	79,16	78,0
1986	90,1	110,9	2,43	112,3	99,0	80,21	83,0
1987	91,3	110,2	2,39	112,9	98,4	80,86	81,0
1988	92,8	111,3	2,37	112,4	98,1	82,56	80,0
1989	87,9	112,5	2,53	112,4	97,3	78,24	81,0
1990	78,9	114,5	2,87	112,4	97,3	70,21	74,0
1991	76,5	111,7	2,89	109,0	95,9	70,20	75,0
1992	<b>73,5</b>	110,7	2,98	105,8	94,4	<b>69,47</b>	<b>72,0</b>
1993	73,7	107,1	2,88	103,6	93,7	71,14	77,0
1994	75,7	106,2	2,78	102,7	93,5	73,67	80,0
1995	75,9	105,9	2,76	101,9	93,2	74,54	83,0
1996	75,0	105,9	2,79	97,7	93,4	76,73	82,0
1997	75,7	<b>105,6</b>	2,76	97,0	93,1	78,00	83,0
1998	73,6	106,0	2,85	<b>96,7</b>	<b>92,6</b>	76,15	82,0

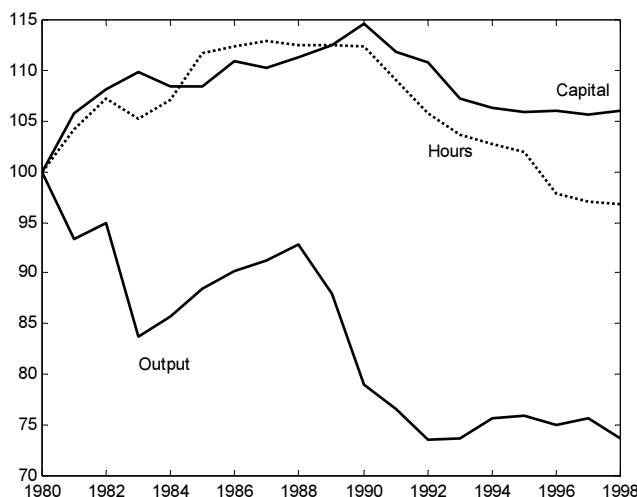
Note: GNP, Capital, (total worked) Hours are series per working age person, Average weekly hours worked is a level index (1980=100) and Industrial capacity utilization is a percentage measure. K/Y denotes the capital output ratio and Y/H the index of hours worked productivity. GNP and capital are detrended by 2% growth rate of output per working age person.

On the other hand, the input series (measured in terms of per working age person) move in opposite directions from trend. Capital moves above trend while total hours worked shows a clear decline, falling 31.1% below trend in 1998. The index of average weekly hours worked drops 2.7% from 1980 to 1990, 1.9% from 1980 to 1988 and more significantly, 4.8%, from 1989 to 1998. Industrial capacity utilization starts at 84% in 1980 and slides to 72% by 1992 and recovers to 82% in 1998.

Capital intensity (K/Y) increases more than 26% from 1980 to 1984, keeping a share of approximately 2.45 from 1985 to 1989. With a 16% jump from 1989 to 1990, this ratio remains at about 2.8 in the 1990s. The index of productivity declines more than 30% from 1980 to 1992. Even though this index slightly improves during the late 1990s, it still remains almost 24% below trend in 1998.

Figure 3 below depicts the dynamics of detrended aggregate output, capital and average hours worked, all in terms of per working age person, from 1980 to 1998. The contributions of the two inputs fail to drive up aggregate output. The decline in output and the rise in capital and labor inputs imply a large drop in the total factor productivity (see Figure 4).

**Figure 3 – Detrended Output, Hours, and Capital Series**



The next section is devoted to quantifying the contribution of these inputs and total factor productivity in order to understand the nature of the Brazilian depression using a standard growth accounting exercise.

### 3. Growth accounting

Brazilian National Income Accounts data identifies the capital share of the economy to be about 50% of output. This measure seems to be quite high according to the international evidence (see Gollin, 2002). Moreover, there is significant unreported income generated by self-employed and family workers. Therefore, we adjust the capital share to account for this unreported income. We implement an approximation method suggested by Gollin (2002) and by Young (1995, p. 655) for East Asian countries using the Brazilian household income survey (PNAD/IBGE). We find that the capital share for Brazil should be approximately 35 percent. Using this parameter value in the aggregate Cobb-Douglas function below, we perform a growth accounting exercise to identify the contribution of capital accumulation, productivity and labor input respectively, in the performance of the Brazilian economy.

$$Y_t = A_t K_t^\theta H_t^{1-\theta} \quad (1)$$

$Y_t$  denotes aggregate output,  $K_t$  capital stock,  $H_t$  total hours worked, and  $A_t$  total factor productivity (TFP).

Taking natural logarithms of the above production function and rearranging terms as in Hayashi and Prescott (2002), we obtain the following expression:

$$\ln\left(\frac{Y_t}{N_t}\right) = \frac{1}{1-\theta} \ln A_t + \frac{\theta}{1-\theta} \ln\left(\frac{K_t}{Y_t}\right) + \ln\left(\frac{H_t}{N_t}\right) \quad (2)$$

where  $N_t$  denotes the working age population. From equation (2), the change in real GDP per capita over the period  $t$  to  $t+s$  can be expressed as:

$$\begin{aligned} \left[ \ln\left(\frac{Y_{t+s}}{N_{t+s}}\right) - \ln\left(\frac{Y_t}{N_t}\right) \right] / s &= \frac{1}{1-\theta} [\ln A_{t+s} - \ln A_t] / s \\ &+ \frac{\theta}{1-\theta} \left[ \ln\left(\frac{K_{t+s}}{Y_{t+s}}\right) - \ln\left(\frac{K_t}{Y_t}\right) \right] / s + \left[ \ln\left(\frac{H_{t+s}}{N_{t+s}}\right) - \ln\left(\frac{H_t}{N_t}\right) \right] / s \end{aligned} \quad (3)$$

where the terms on the right-hand side of this equation, from left to right, are the contribution to growth of changes in TFP, in capital intensity and, in hours worked per working-age person respectively. On a balanced growth path, the second and the third terms are equal to zero once the capital-output ratio and the hours worked per working-age person are constant, hence all growth is attributed to changes in TFP for the growth accounting exercise. Therefore, as in Bergoeing, Kehoe, Kehoe, and Soto (2002), it is assumed in this numerical exercise that changes in output not related to changes in TFP are associated to deviations of investment and work effort decisions from their respective balanced-growth behavior.

Table 4 below presents the growth accounting for Brazil. Over the period 1980-1998, the Brazilian economy grew at an annual rate of 0.28% (per working age person), well below the average annual growth rate of 4.25% observed from 1950 to 1980. This performance can be attributed to a negative  $-0.62\%$  contribution of TFP,  $1.09\%$  growth of the capital output ratio and,  $-0.18\%$  change in hours worked per working age person.

During the first sub-period 1980-1988 the economy stagnated, growing at an annual rate of  $1.06\%$ . This performance was driven mostly by the more intensive use of inputs. This is shown by the positive growth rates of the capital-output ratio ( $1.22\%$ ) and the hours worked ( $1.47\%$ ), which compensate a negative contribution of TFP ( $-1.63\%$ ).

From 1989 to 1992, the Brazilian economy shrunk. Per capita GDP grew at a negative rate of  $-4.00\%$ . During this period, capital intensity grew by  $2.94\%$  but was

completely offset by (i) a significant negative contribution of TFP (-4.92%) and (ii) in the hours per working age (-0.02%).

Finally, the sub-period 1993-1998 appears to be a recovery period. Per working age GNP grew at 1.96%. Contrary to previous sub-periods, the TFP growth rate of 3.45% completely offset the small but negative contributions of inputs growth rate, i.e. K/Y (-0.11%) and H/N (-1.38%).

**Table 3. Growth Accounting (%), Brazil (1980-1998)**

Period	Y/N	TFP	K/Y	H/N
1980-1998	0.28	-0.62	1.09	-0.18
1980-1988	1.06	-1.63	1.22	1.47
1989-1992	-4.00	-4.92	2.94	-2.02
1993-1998	1.96	3.45	-0.11	-1.38

#### 4. Numerical experiments with the growth model

The above growth accounting had shown that for the Brazilian experience, the contribution of changes in TFP has been the most important factor behind the country's economic performance. Nevertheless, the same exercise suggests that the contribution of changes in the investment rate and in the labor input to the dynamics of per capita GNP were significant as well.

We calibrate a standard neoclassical growth model with divisible labor to quantitatively assess the contribution of these changes. Theoretically, the agents of the artificial economy generate optimal inter-temporal decision rules given a deterministic path of TFP. Then the artificially generated series of optimal decisions are used to assess the ability of the model to explain the observed dynamics.

##### 4.1. The growth model

The growth model consists of a closed economy. Denoting all variables in efficiency units of labor, the representative household's utility is defined over sequences of consumption  $\{c_t\}$  and leisure  $\{l_t = 1 - h_t\}$  chosen to solve the following problem,

$$\max E \left\{ \sum_{t=0}^{\infty} \beta^t (1 + \eta)^t [\ln(c_t) + \alpha \ln(1 - h_t)] \right\} \quad (4)$$

subject to the per period budget constraint. By assumption, our artificial economy has no distortions. Therefore, applying the Second Welfare Theorem, the equilibrium

allocation under the Planner's problem will be the same as the one obtained under the competitive equilibrium. This theorem allow us to maximize (4) subject to

$$c_t + x_t = z_t(1 + \gamma)^{(1-\theta)t} k_t^\theta h_t^{1-\theta} \quad (5)$$

where  $h_t$  represents hours of work,  $\eta$  the population growth rate,  $\alpha$  a parameter affecting the disutility of working,  $\beta$  the discount rate, such that  $0 < \beta < 1$ ,  $k_t$  the per household available capital stock,  $\theta$  the capital share in output and  $x_t$  investment. Following the notation used in equation (1) above,  $A_t = z_t(1 + \gamma)^{(1-\theta)t}$  where  $z_t$  is a stationary component of TFP and  $\gamma$  the rate of technical progress. The exogenous shock to productivity,  $z_t$ , is a stationary stochastic process with a law of motion given by

$$z_{t+1} = 1 - \rho + \rho z_t + \varepsilon_t \quad (6)$$

where  $\varepsilon_t$  is assumed to be a white noise innovation process and,  $0 < \rho < 1$  describes its persistence.

Finally, the law of motion for capital stock is given by:

$$k_{t+1} = (1 - \delta)k_t + x_t \quad (7)$$

Therefore, on the balanced growth path, output, consumption and capital will grow at the same rate given by  $(1 + \eta)(1 + \gamma)$ .<sup>7</sup>

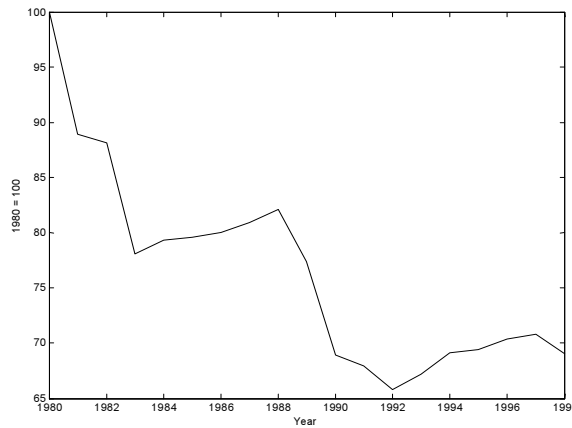
#### 4.2 Calibration and Simulation

The model economy is calibrated according to Cooley and Prescott's (1995) procedure. The calibration reproduces the steady-state features of the Brazilian economy before the depression. For 1950-1980, the population growth rate is  $\eta = 2.9\%$  and the average growth rate of technical progress is  $\gamma = 1.3\%$ . This value of  $\gamma$  is obtained according to a 2% trend of per working age GNP and a capital share in aggregate output of 35%, i.e.  $(1.02)^{(1-0.35)} = 1.013$ . The depreciation rate is calibrated as  $\delta = 9\%$ .

The calibration of the discount factor is based on the first order condition for capital,  $\beta = 0.90$ . This value is derived using the average capital-output ratio for the period 1970-1980, i.e.  $(K/Y)_{1970-1980} = 1.62$ . The parameter associated to the disutility of working,  $\alpha$ , is in turn obtained from the labor Euler equation and the stylized fact

that shows agents spend 40% of total available time for market activities.<sup>8</sup> The fraction of time allocated to the market activities is the workweek divided by the total time available to the agents, that is 16 hours - 7 days per week. Hence,  $\alpha$  is set to 1.28. Finally, to calibrate the persistence of the productivity shock given by  $\rho$ , a AR(1) regression is run with the detrended TFP (see Figure 4), generating a parameter value of 0.97.

**Figure 4 – Detrended TFP, Brazil (1980-1998)**



*Simulation strategy and initial conditions:* The optimal decision rules are computed using a linear quadratic approximation method to the above optimization problem translated into a dynamic programming problem. The simulation of the artificial economy begins in 1980. Therefore, we need to set the initial values for the two state variables  $k_{1980}$  and  $z_{1980}$ . For the technological shock we assume its steady-state value, i.e.  $z_{1980} = 1$ . For the capital stock, we need the actual value in terms of the steady-state variables. To get this value, the steady state output is multiplied by the actual capital-output ratio of the economy in 1980, i.e.  $(K/Y)_{1980} = 1.98$ . Then, for  $t = 1981, \dots, 1998$ , we use a detrended index of the TFP such that  $z_{1980} = 1$ . This sequence and the decision rules of investment and hours are taken to produce the dynamics of the artificial economy.

<sup>7</sup> For a more detailed description of the neoclassical growth model refer for example to Kehoe and Prescott (2002), Cooley and Prescott (1995) or Hansen (1985).

<sup>8</sup> This value is computed using the Brazilian Household Survey data from 1970-1998. See appendix for details.

### 4.3 Findings

The results, numerically computing the competitive recursive equilibrium of the above model economy, are analyzed in this section. In Table 4 we show the growth accounting of the simulated series.

Comparing Tables 3 and 4 we see that, for the whole period, the artificial economy generates a deeper recession. This result is due to the behavior of the artificial economy in the first two sub-periods where the depression is overstated by the model.<sup>9</sup> Despite this, the shape of artificial output is close to the behavior of real output (see Figure 5).

**Table 4. Model Growth Accounting (%), Brazil (1980-1998)**

Period	Y/N	TFP	K/Y	H/N
1980-1998	-0.72	-0.62	-0.14	0.04
1980-1988	-1.54	-1.63	0.12	-0.03
1989-1992	-4.38	-4.91	0.78	-0.25
1993-1998	2.75	3.45	-1.04	0.34

As we can see in Figure 5 and 6, (a) to (d), in general the model performs well. In particular, with respect to aggregate output, the model reproduces the falling aggregate output dynamics that we see in the data. The same is true with respect to the movements of consumption and investment as well (Figure 6, (a) and (b)). Therefore, we can assess that the technological shocks introduced in the standard neoclassical growth model can fairly explain the performance of the Brazilian economy during the period we consider.

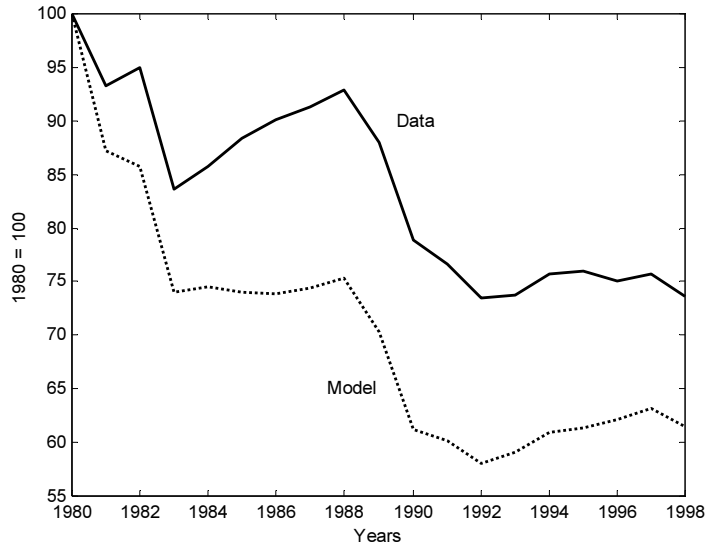
Nonetheless, we should stress that the model fails match the data for the capital stock and hours worked series (Figure 6, (c) and (d)). A closer look at the particular characteristics prevailing in the Brazilian economy during the analyzed period is in order. These specifics could explain the limited performance of the artificial economy in regard to those two series.

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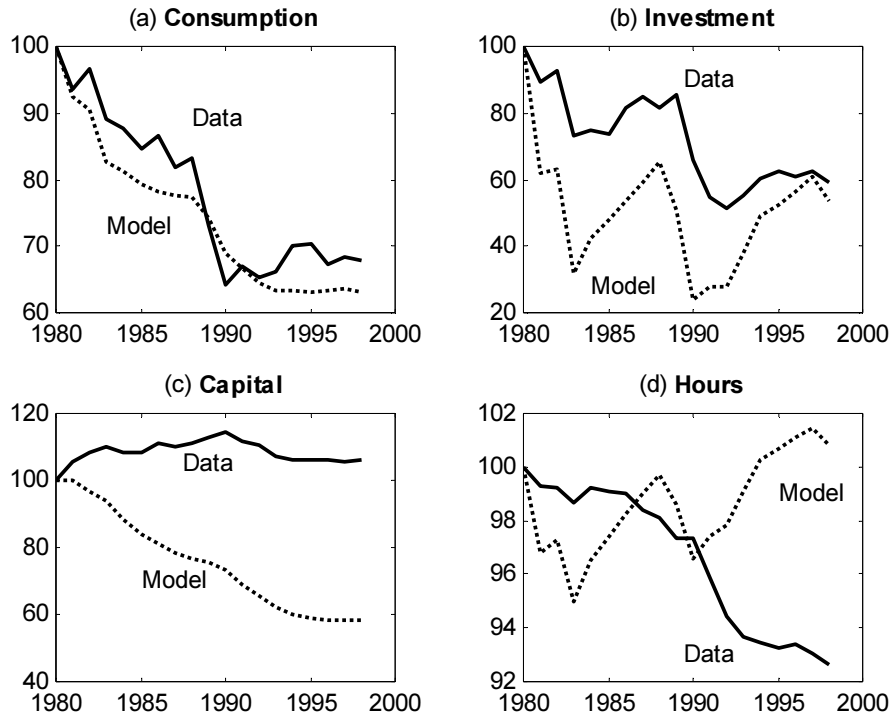
<sup>9</sup> We will come back to this point later on in this section. We believe that changes in the workweek and in the tax system after 1988 can be used to explain this discrepancy.

**Figure 5 – Detrended Aggregate Output Dynamics, Brazil (1980-1998)**

**Data and Artificial Series**



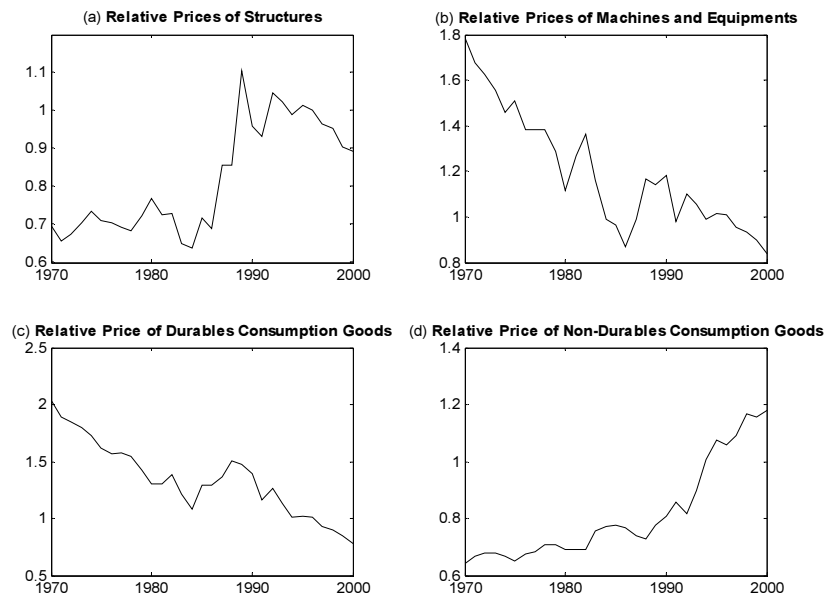
**Figure 6 – Data and Model Dynamics**



## 5 Remarks on the findings

In this section we analyze some features of Brazilian economy that can explain why the model fails to reproduce the behavior of the capital stock and hours worked. From the 1980s up to the early 1990s, the price level of the structures sector<sup>10</sup> grew much faster than the price level of the economy<sup>11</sup> as depicted in Figure 7.

**Figure 7 – Relative Price of Investment and Consumption Goods, 1970-2000**



Bacha (1993) suggests that there could be four possible reasons for the increase in the relative price of investment in the 1980s in Argentina, Brazil and Colombia: the real devaluation of domestic currency; the increases of “listed” prices of investment goods and construction contracts to compensate for higher expected inflation; the substitution of less efficient domestically produced capital goods for

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<sup>10</sup> The relative price of the structures sector is constructed as the ratio of a wholesale price index specific to the structures sector and a general wholesale price index. The same methodology is used to calculate the relative price of machines and equipment, durable consumption goods and non-durable consumption goods. Structures account for 65.6% of the total capital stock, and machines and equipment account for 28.1%.

<sup>11</sup> See Carneiro and Werneck (1993) and Bacha (1993) for a study of this relative price in Brazil during the period under study.

more efficient imported ones; and the oligopolistic behavior of domestic capital good producers.

We think that one important reason for the increase in the relative price of investment goods, especially construction in Brazil, is due to several shocks to the economy during the 1980s and early 1990s. During this period, the Brazilian economy had very high rates of inflation. The government attempted to stabilize the skyrocketing inflation rate with so-called “heterodox plans”. From 1986 to 1991, Brazil experienced six of these (unsustainable) plans. The main instrument of these plans was a price “freeze”, prohibiting firms from changing prices. These plans increased the instability of the Brazilian economy, giving people the incentive to look for hedges. The most common mechanism of protection under this increasingly unstable situation consisted of real estate purchases such as apartment buildings, that pushed up their relative price.

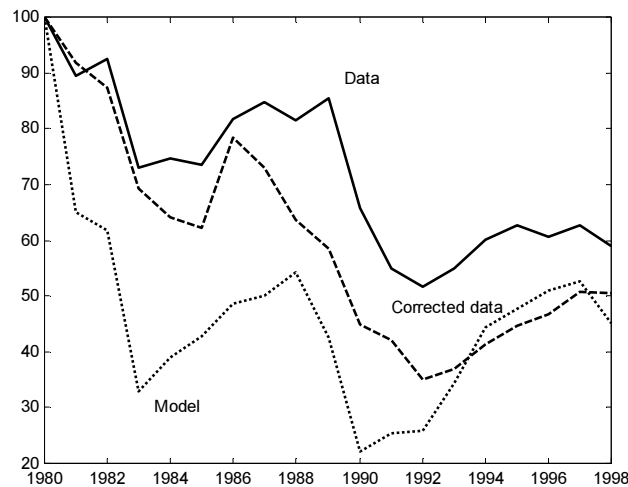
A second shock that hit the Brazilian economy was the government default on its internal debt in 1990. This default came as part of another “heterodox plan”, known as “Collor Plan”. This scheme was named after the president who passed this bill in the Congress in March 1990. Prior to this (expected) default, people tried to protect their savings, shifting their demand toward real estate properties. This shift also contributed to increase in the relative price of investment goods.

This relative price effect has crucial implications since it can lead to an overestimation of spending on investment in structures. Consequently, it overestimates both the investment and the capital stock series. Since we use the perpetual inventory method, this annual overestimation acts cumulatively on the capital stock series. It drives up the capital stock series, even during the recession, whereas in our model economy capital stock is going down. This effect does not appear in the investment series because it is a flow variable. Hence, each annual overestimation does not sum up over time in this series as it does with capital.

The recomputed investment series, corrected for this changes in relative prices is shown in Figure 8. This figure shows three series. The first one refers to the investment data without correcting for changes in relative prices. The second series is the same data corrected for the relative price variation. Once the investment series is corrected for changes in the relative price of investment goods to general prices of the economy, this series shifts down. As expected, the overestimation of investment due to this relative price phenomenon is substantial during the second half of the 1980s.

Once the investment series is corrected for relative price changes, the capital stock series is also recomputed. The new capital stock series is shown in Figure 9 below. This graph shows three series of capital stock. The first one from the top corresponds to the capital stock series based on the raw investment series. The second series is constructed with the investment series adjusted for changes in relative prices. Once the investment series is corrected for this relative price change, the capital stock series shifts down considerably. We compute an artificial series using the standard growth model. In this case, the capital stock obtained with the relative price corrected investment series is used to set the initial capital stock of the model economy. This artificial capital stock series (the lowest series in the graph) is able to mimic the declining behavior of the corrected capital stock data remarkably well.

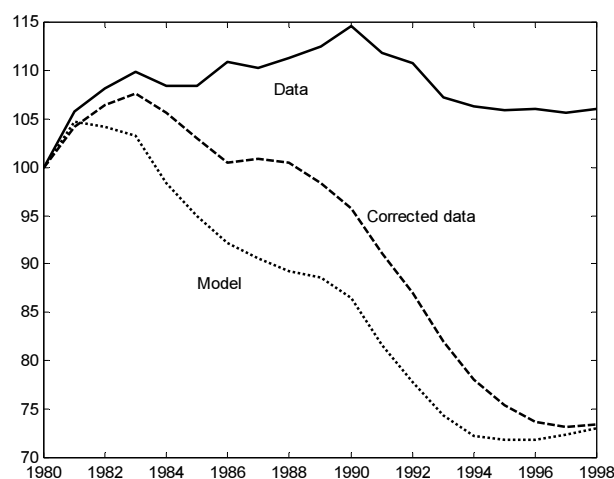
**Figure 8 – Detrended Investment Series Dynamics, Brazil (1980-1998)  
Data, Corrected Data and Model with Corrected Data**



Finally, as stated above, the model also does not perform well with respect to the observed series of hours worked (Figure 6, (d)). The new institutional framework introduced by the Brazilian 1988's constitutional reforms may explain the failure of the model to replicate the data. In 1988, Brazil adopted a new Constitution that introduced many institutional changes. In particular, a mandatory reduction in the workweek was instituted. Moreover, due to an attempt to balance the public sector budget and a significant decentralization of tax revenues brought about by the reformed Constitution, many new taxes were created from 1989 on. These tax increases on labor income distort the people's optimal inter-temporal decisions. The

changes in the tax system increased the Brazilian tax share on GDP from 22.4% in 1988 to 31.7% in 1998.

**Figure 9 – Capital Stock Series, Brazil (1980-1998)**  
**Data, Corrected Data and Model with Corrected Data**



This significant increase of labor taxes in Brazil during the period under study, in addition to technology shocks and the legal changes in the workweek, could explain the reduction in hours worked for the period 1988-1992<sup>12</sup> even though the productivity started to increase in 1992.

## 5. Conclusions

In this paper we use the neoclassical growth model with exogenous technology shocks to study the behavior of the Brazilian economy during the 1980s and 1990s. In particular, the model indicates that the technology shocks can account for the depression of the Brazilian economy during the 1980s and 1990s.

There are two areas to extend our work. First, we could expand the model to introduce changes in relative prices. Even though we speculate about reasons for the increase in the relative price of investment goods, we think there is room to introduce changes in the model to account for this abrupt jump that we see in the data. Second,

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<sup>12</sup> It seems that the reduction in the workweek is not binding in this period. In our model, see figure 4.2, the number of hours fall even without introducing this new constraint. This indicates that was optimum for the consumers to reduce the number of hours worked.

we could explicitly consider the government and tax system in the model to assess the impact of changes of labor taxation on the optimal decision of hours worked.

Introducing those extensions should improve the ability of the model to explain the Brazilian depression. First, once we introduce the government into the model economy, we can characterize the government investment decision. Hence, total investment may increase in the artificial economy because government investment does not take into account the marginal productivity of capital when deciding the amount of resources to be invested. Second, introducing taxes may be able to account for changes in labor supply and demand for labor as well.

The final question to be addressed is why the productivity does not recover after the external shocks of the 80s. One explanation of this behavior is similar to the Bergoeing, Kehoe, Kehoe and Soto (2002b) hypothesis that government policy distorted the allocations of resources both within and across sectors in Chile and Mexico. In the Brazilian case, this distortion may affect both the allocations of capital and labor.

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