



Universidade de Brasília  
Departamento de Economia

Série Textos para Discussão

## **The Brazilian Depression in the 1980s and 1990s**

***Mirta N. S. Bugarin***

Universidade de Brasília

***Roberto de G. Ellery Jr.***

Universidade de Brasília

***Victor Gomes***

Universidade de Brasília

***Arilton Teixeira***

IBMEC-Rio

Texto nº 235  
Brasília, Agosto de 2002

Department of Economics Working Paper 235  
University of Brasilia, August 2002

**UNIVERSIDADE DE BRASÍLIA  
DEPARTAMENTO DE ECONOMIA**

**TEXTO PARA DISCUSSÃO Nº 235**

**The Brazilian Depression  
in the 1980s and 1990s**

***Mirta N. S. Bugarin***

Universidade de Brasília

***Roberto de G. Ellery Jr.***

Universidade de Brasília

***Victor Gomes***

Universidade de Brasília

***Arlton Teixeira***

IBMEC-Rio

Brasília, 30 de agosto de 2002

**UNIVERSIDADE DE BRASÍLIA**  
**DEPARTAMENTO DE ECONOMIA**  
**Campus Universitário Darcy Ribeiro**  
**Instituto Central de Ciências**  
**Caixa Postal 04302, 70910-900 Brasília, DF, Brasil**  
**Tel.: (55-61) 3072498, 2723548**  
**Fax: (55-61) 3402311**  
**E-mail: econ@unb.br**  
**<http://www.unb.br/ih/eco>**

***Chefe do Departamento***

**Prof. Flávio Rabelo Versiani**

***Sub-Chefe do Departamento***

**Prof. Jorge Madeira Nogueira**

***Coordenador de Pós-Graduação***

**Prof. André Rossi de Oliveira**

***Coordenador de Pesquisa e Extensão***

**Prof. Maurício Soares Bugarin**

***Coordenador de Graduação***

**Prof. Jorge Madeira Nogueira**

**SÉRIE DE TEXTOS PARA DISCUSSÃO**

***Comissão Editorial, mandato junho de 2001 a setembro de 2002***

**André Rossi de Oliveira**

**Bernardo Mueller**

**Flávio Versiani**

**Jorge Nogueira**

**Maurício Bugarin (editor)**

**Mauro Boianovsky**

**Apoio: CESPE UnB**

# The Brazilian Depression in the 1980s and 1990s

Mirta S. Bugarin<sup>\*</sup>

Roberto Ellery Jr.<sup>†</sup>

Victor Gomes<sup>‡</sup>

Arlton Teixeira<sup>§</sup>

## 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 worked hours. 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.

*Journal of Economic Literature Classification Code:* E13, E32, O40

*Key Words:* Depression, Growth Model, Brazil

---

<sup>\*</sup> Departamento de Economia, Universidade de Brasília; mirta@unb.br.

<sup>†</sup> Departamento de Economia, Universidade de Brasília; ellery@unb.br.

<sup>‡</sup> Diretoria de Estudos Setoriais, Instituto de Pesquisa Econômica Aplicada (IPEA); victor@ipea.gov.br.

<sup>§</sup> Departamento de Economia, Instituto Brasileiro de Mercados de Capitais (IBMEC); arilton@ibmecrj.br.

## 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 depressed more than 25% below trend.

What enables the Brazilian crises to be consider a depression? According to Kehoe and Prescott (2002, pp. 8-10) a depression is characterized by a sufficiently large and persistent deviation of aggregate output per working age person from its trend, such that it remains at least 20% below trend, falling at least 15% within the first decade of the depression. The Brazilian GNP per working-age person dropped, approximately, less than 20% below trend during the 1980s and 25% in the 1990s (see Figure 1).

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



The objective of this paper is to study the Brazilian depression from the perspective of the general equilibrium growth model. In this way, we follows the line of research proposed by Cole and Ohanian's (1999) analysis of the Great Depression in the United States. Many authors has proving that the variants of the general equilibrium growth model are useful to study depressions, from the interwar period in Europe and North America and from more recent

---

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

times in Japan and Latin America.<sup>2</sup> Concerning Latin American cases, 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.

Our main results show that the growth model can describe its experienced contraction in the 1980s and the 1990s. The actual behavior in output, consumption and investment are reproduced by the standard growth model. The artificial series for hours worked and capital stock fails to mimic the observed dynamics.

Nevertheless, once the data were corrected by the significant distortion of the relative price of investment observed in the country, the improvement of the model's ability to describe the observed dynamics of series of capital and investment is indeed noteworthy.

The worked hours generated by the model economy also appears to be short in explaining the observed motion, in particular after 1990. In this case, the specific institutional changes introduced by the Brazilian Constitutional reform in 1988, especially on the weekly workable hours, helps to understand the obtained results.

The rest of the paper is divided as follows. Section 2 briefly presents the main empirical evidences of the Brazilian "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 find in the numerical simulation of the standard model. Section 6 concludes discussing the implications of the results for ongoing and future research.

## **2. The empirical facts**

Among other Latin American countries, Argentina, Mexico and Chile also showed a deep depression during the 1980s. Argentinean GNP per working age person dropped 37% below trend in 1990 according to Kydland and Zarazaga (2002),

---

<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*.

the Chilean one approximately 20% below trend in 1983 and, the Mexican about 40% below trend in 1993 (Bergoeing, Kehoe, Kehoe, and Soto, 2002a).

In terms of its persistence, the Brazilian depression is only similar to the ones experienced by Mexico and Argentina in the 1980s and 1990s and by New Zealand during the period 1974-1992.<sup>3</sup> Similar to these Latin American countries, the Brazilian contraction lasted at least 10 years or more than 2 times the U.S. Great Depression.

Moreover, according to the definition of depression herein considered, the Brazilian is not a big one when compared with other depression experiences.<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 the Brazilian data given by its national accounts are analyzed.<sup>5</sup> Since the aim is to understand the deviations from trend of the main aggregate series all data has been detrended. Table 1 presents the detrended indexes of the per working age output and its components, indicating in bold format the respective lowest level for 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

---

<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.

GNP per working age person dropped 26.5% below trend. There are two sub periods where the economy shows some signs of recovery: during 1985-1988 and, much more timidly, from 1993 to 1997. But this reaction was not able to bring the economy back to its peak of 1980. At the end of the 1990s the Brazilian economy still remained 26.4% below trend.

All aggregate demand components did not reach, in any considered year, the respective 1981's level except for government consumption, which increased more than 35%, from 1981 to 1998. The import index shows a declining participation of foreign goods in domestic absorption, shrinking almost 60% from 1980 to 1989, still remaining about 35% below trend along the 1990s. The export index, on the other hand, drops down 43% below its 1980's level 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.	Government' Invest.	Government' 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 below shows the share of aggregate consumption, investment, government expenditures, exports and imports as shares of GDP for the period 1980-1998. Aggregate consumption participation drops from 59% in 1980 to 50% in 1990 and still in 1998 do not recover the 1980's share. Investment's participation, on the other side, starts with a participation of 34% in 1980, it falls to 27% in the initial years

of depression, and rose 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 stock of capital in the subsequent time period (see Table 3 below).<sup>6</sup> It is noteworthy that government expenditure share in aggregate output steadily increases 100% from 1980 to 1998. Imports and exports do not show a clear pattern and remain in 1998 about the same figures of 1980. In the case of exports, this component of output rose in the first years of the depression but recover 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 below presents in turn the Brazilian detrended aggregate output (GNP) and inputs per working age person, the capital output ratio (K/Y), the productivity of worked hours (Y/H) and the percentage of industrial capacity utilization. As the data indicates, during the three first years of the contraction, worked hours and capital do

<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 to 8% in 1932. This figure represents a drop of 68% of investment share. In the first years of Brazilian

not fall below their respective trend, as does the real GNP per working age person. The latter falls down 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 weekly hours	Y/H	Industrial 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 worked hours 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 worked hours productivity. GNP and capital are detrended by 2% growth rate of output per working age person.

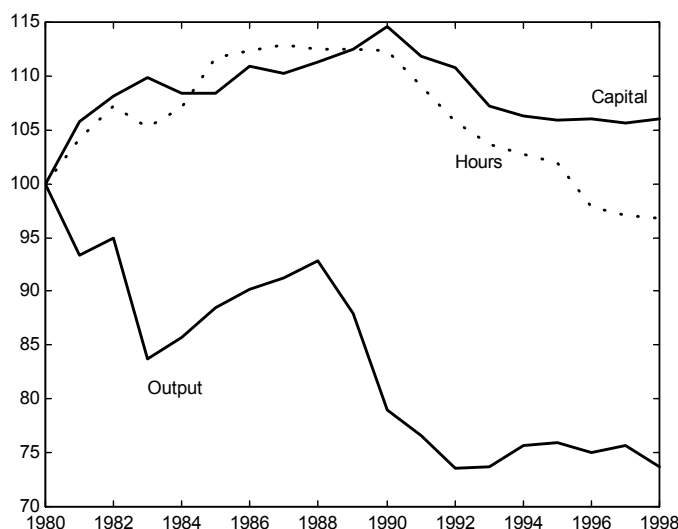
On the other side, input series measured in terms of per working age person move in opposite directions from trend. Capital series moves up from trend during the entire considered period whereas total worked hours show a clear decline to a deepest 31.1% deviation from trend in 1998. The index of average weekly worked hours drops mildly 7.4% from 1980 to 1990, 1.9% from 1980 to 1988 and more significantly, 4.8%, from 1989 to 1998. Industrial capacity utilization starts from 84% in 1980 and slides down 28% at its most in 1992, recovering to 82% in 1998.

crises the investment share drops 21%, than we can state that the drop of investment share was modest in the Brazilian depression.

Capital intensity ( $K/Y$ ) series 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 along the 1990s. The index of worked hours productivity, in turn, decreases more than 30% from 1980 to 1992. Even though this index slightly improves during the late 1990s, it still remains almost 24% below the 1980 level in 1998.

Figure 3 below depicts the dynamics of detrended aggregate output, capital and average worked hours, all variables in terms of per working age person, from 1980 to 1998. It is visually clear that the contributions of the two inputs fail to drive up the detrended aggregate output. These two contributions to aggregate output together with the complementary contribution of the total factor productivity generates the dynamics of the Brazilian output in the 1980s and 1990s. The decline in output and the rise in capital and labor inputs generate a large drop in the total factor productivity (see Figure 4 below in p. 13).

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



The next section is devoted to quantify these inputs and the total factor productivity contributions in order to understand the nature of this Brazilian depression by means of a standard growth accounting exercise.

### **3. Growth accounting**

A look at the 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, the significant unreported income generated by self-employed and family workers in Brazil should be considered. Hence, a treatment of this share measure seems to be in order. In particular, considering the significant unreported income generated by self-employed and family workers in Brazil. In order to cope with possible measurement errors, an approximation method suggested by Gollin (2002) and by Young (1995, p. 655) to East Asia countries is implemented based on the Brazilian household income survey (PNAD/IBGE). Implementing this approximation, the capital share for Brazil should be approximately 35 percent. Then, with this parameter value in hand the aggregate Cobb-Douglas function below is used to proceed with the growth accounting exercise aiming to identify the contribution of capital accumulation, productivity and labor input respectively, to the performance of the Brazilian economy.

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

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

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

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

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 obtained as:

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

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. For the entire considered period 1980-1998, the Brazilian data show that the 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 worked hours 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 worked hours ( $1.47\%$ ), which compensate a negative contribution of TFP ( $-1.63\%$ ).

From 1989 to 1992, the Brazilian economy enters a period of depression. Per capita GDP showed a negative growth rate of  $-4.00\%$ . Along this period, capital intensification grew as much as  $2.94\%$  but it is completely offset by (i) a significant negative contributions of TFP ( $-4.92\%$ ) and (ii) in the hours per working age ( $-2.02\%$ ).

Finally, the sub period 1993-1998 appears to be as 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 important as well.

A standard neoclassical growth model with divisible labor will be next calibrated to quantitatively assess the contribution of these changes. Theoretically the agents of the artificial economy will generate optimal inter-temporal responses to this perfectly foreseen exogenous productivity shocks. Then the artificially generated series of inputs optimal responses is 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 in which agents have perfect foresight over the exogenous productivity shocks to the economy. Denoting all variables in efficiency units of labor, the representative household's utility is defined over sequences of consumption  $\{c\}$  and leisure  $\{l = l - h\}$  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 will be 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) guidelines. 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  $\delta = 9\%$ .

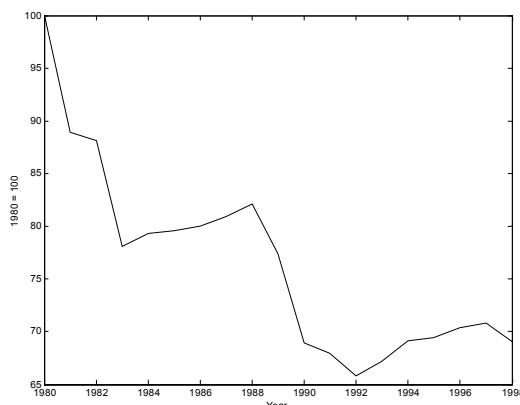
The calibration of the discount factor is based on the first order condition for capital,  $\beta = 0.90$ . This value is derived using the average capital-output ratio for the period 1970-1980, i.e.  $(K/Y)_{1970-1980} = 1.62$ . The parameter associated to the disutility of working,  $\alpha$ , is in 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), setting this parameter value to 0.97 according to this estimation.

---

<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.

**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.

### 4.3 Findings

The obtained 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 artificially obtained series.

Comparing Tables 3 and 4 we see that, for the whole period, the artificial economy presents a deeper recession. This result is due to the behavior of the artificial economy in the first two sub periods in which 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)**

<b>Period</b>	<b>Y/N</b>	<b>TFP</b>	<b>K/Y</b>	<b>H/N</b>
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), below, 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 along the considered period.

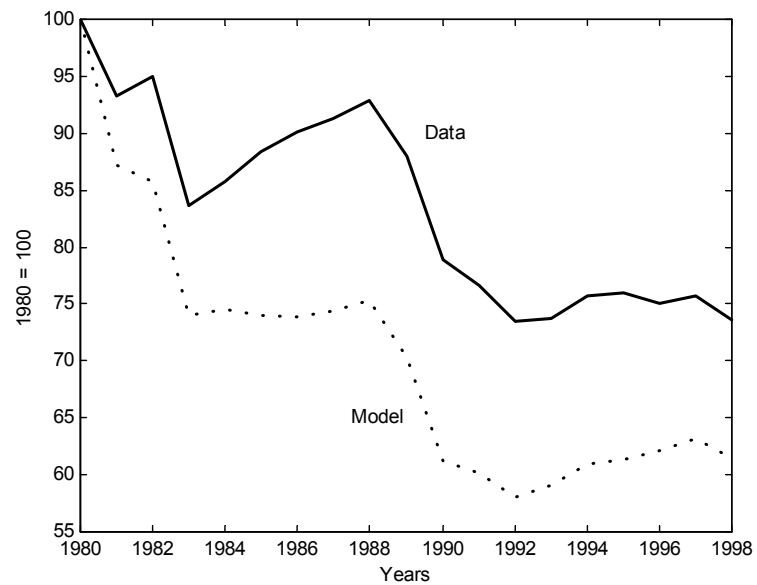
Nonetheless, we should stress that the model does not deliver such a clear understanding regarding the evidence on capital stock and worked hour series (Figure 6, (c) and (d)). A closer look at the particular characteristics prevailing in the Brazilian economy during the analyzed period seems to be in order. These specifics could explain the limited performance of the artificial economy in regard to the evidence on those two series.

---

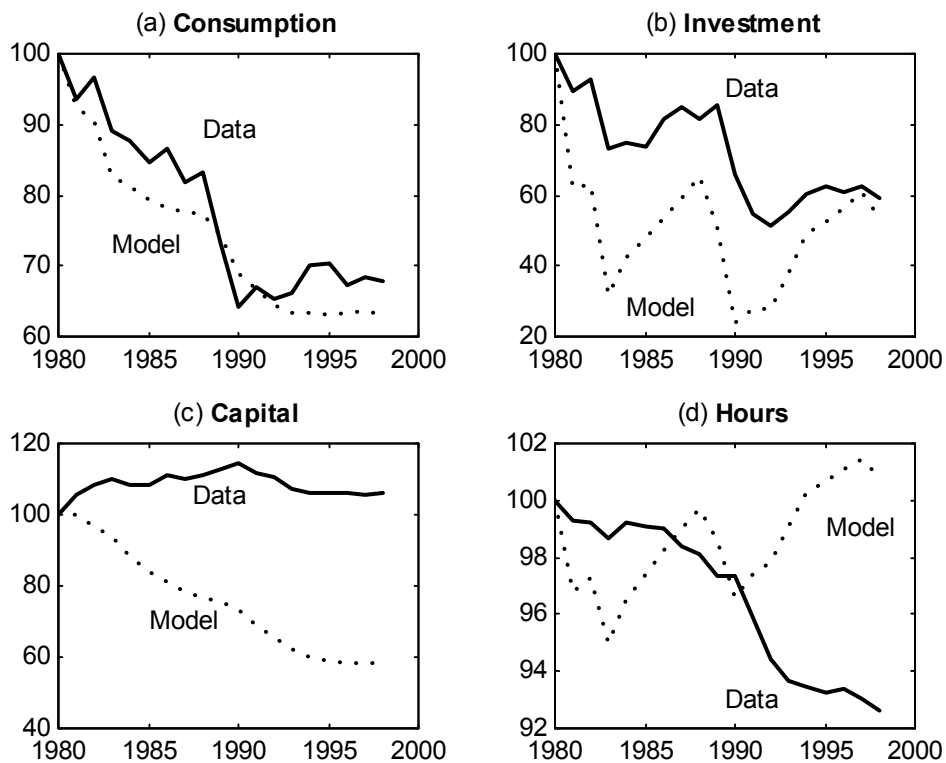
<sup>9</sup> We will come back to this point later on in this section. We believe that changes in the workweek and in the tax system after 1988 can be used to explain this discrepancy .

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

**Data and Artificial Series**



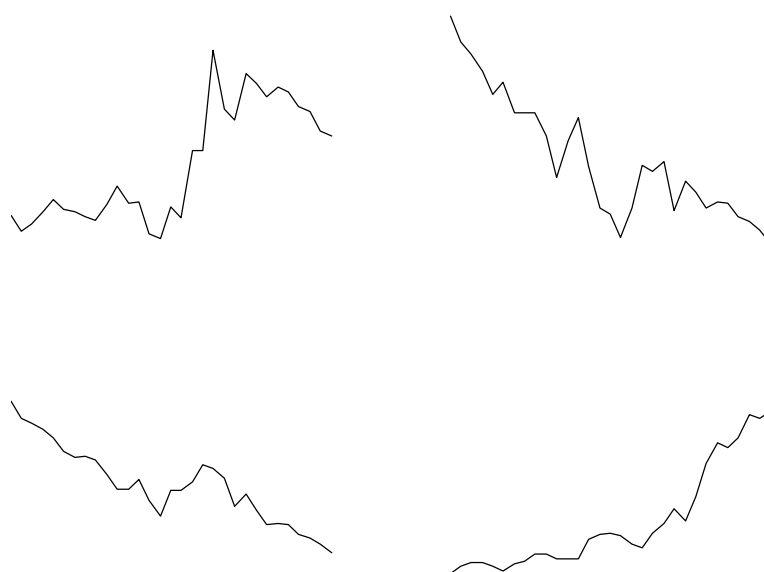
**Figure 6 – Data and Model Dynamics**



## 5 Remarks on the findings

In this section we trace some comments that can explain the why the model fails in reproduce the behavior of the stock of capital and in the hours worked. Along the 1980s up to the early 1990s, the price level of the structure 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 along the 1980s in Argentina, Brazil and Colombia as well. Namely, 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 more efficient imported ones and, the oligopolistic behavior of domestic capital good producers.

---

<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.

Then, we can speculate that one important reason for the increase in the relative price of investment goods, especially construction in Brazil, is due to several shocks that hitched the economy during the 1980s and early 1990s. During this period, the Brazilian economy lived with very high rates of inflation. The government aiming to stabilize the skyrocketing inflation rate implemented the so-called “heterodox plans”. From 1986 to 1991, Brazil experienced six of those (unsustainable) plans. The main instrument of these plans consisted of price “freeze”, prohibiting firms to change prices. These plans increased the instability of the Brazilian economy, once the agents had the right incentives to look for hedges. The most common mechanism of protection under those increasingly unstable situation consisted of real state purchases as apartment buildings, pushing up their relative prices.

A second shock that strongly 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 elected president who passed this bill in the Congress in March 1990. Prior to this (expected) default, the agents tried to protect their savings, shifting their demand toward real state items. This shift also contributed to increase the relative price of investment goods.

This relative price effect has crucial implications due to the fact that it can cause an overestimation in the spending on investment in structure. Consequently, it overestimates investment and the capital stock series as well. Since we use the perpetual inventory method, this annual overestimation acts cumulatively on the capital stock series. This drives in turn the capital stock series up, 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 below. 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. As we can see, once the investment series is corrected for changes in the relative price of investment goods to

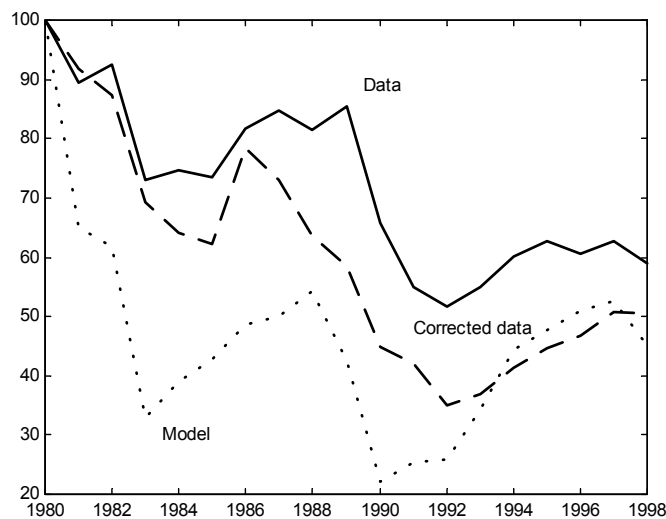
---

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

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 adjusted investment series for changes in relative prices. As we can see once the investment series is corrected for this relative price changes, the newly obtained capital stock series shifts down in a considerable manner. Then, an artificial series is computed 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. It is remarkable that now this artificial capital stock series (the lowest series in the graph) is able to mimic the declining behavior of the corrected capital stock data.

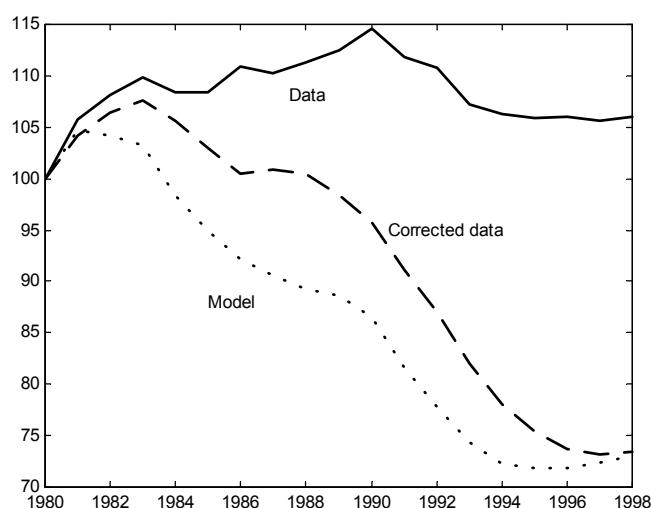
**Figure 8 – Detrended Investment Series Dynamics, Brazil (1980-1998)**  
**Data, Corrected Data and Model with Corrected Data**



Finally, as stated above, the model also does not perform well with respect to the observed series of worked hours (Figure 6, (d)). Even though it is hard to understand the reason behind this finding, the new institutional framework introduced by the Brazilian 1988's constitutional reforms should be considered. In 1988, Brazil adopted a new Constitution that brought many institutional changes. In particular, a

mandatory reduction in the workweek hours was introduced. Moreover, given the objective of pursuing a more balanced public sector budget and a remarkable decentralization of tax revenues brought about by the reformed Constitution, many new contributions (taxes) were created from 1989 on.<sup>12</sup> These distortions increases even further the taxation on labor input as well as on labor income that affects the agents' optimal inter-temporal decisions. These 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 tax effort in Brazil during the period under study could explain, in addition to the technological shocks and to the legal changes in the workweek, the reduction in worked hours for the period 1988-1992<sup>13</sup> even though the productivity started to increase in 1992.

## 5. Conclusions

In this paper we use the neoclassical growth model with exogenous technological shocks to study the behavior of the Brazilian economy during the 1980s

---

<sup>12</sup> For instance the Social Contribution on Net Profits was introduced in 1989. According to Rezende (2001) the actual tax system introduces more distortions harming efficiency as well as competitiveness.

<sup>13</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 worked hours.

and 1990s. In particular, the model indicates that the technological shocks can account for the depression of the Brazilian economy during the 1980s and 1990s.

In order to extend the ongoing research we suggest two points. First, we should try to expand the model to introduce changes in relative prices. Even though we speculate about reasons for the increment of 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, we should explicitly consider the government and a tax system in the model aiming to assess the impacts of changes of labor taxation on the optimal decision of worked hours.

Introducing those extensions we expect to be able to improve the ability of the model in explaining the observed Brazilian depression. First, because once introducing the government into the model economy we can characterize the government investment decision. Hence, total investment can increase in the artificial economy because government investment does not take into account the marginal productivity of capital to decide the amount of resources to be invested. Second, because the tax system can 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. Possible explanations of this behavior seem to be like Bergoing, 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 possibly affects not only the allocation of capital but also the allocation of labor.

## References

Amaral, Pedro S. and James C. MacGee (2002), "The Great Depression in Canada and the United States: a neoclassical perspective", *Review of Economic Dynamics*, 5 (1), pp. 45-72.

Bacha, Edmar L. (ed.) (1993), *Savings and Investment Requirements for the Resumption of Growth in Latin America*, Johns Hopkins University Press.

Beaudry, Paul and Franck Portier (2002), "The French Depression in the 1930s", *Review of Economic Dynamics*, 5 (1), pp. 73-99.

- Bergoing, Rafael, Patrick J. Kehoe, Timothy J. Kehoe, and Raimundo Soto (2002a), “A decade lost and found: Mexico and Chile in the 1980s”, *Review of Economic Dynamics*, 5 (1), pp. 166-205.
- \_\_\_\_\_. (2002b). “Policy-driven productivity in Chile and Mexico in the 1980s and 1990s.” *American Economic Review*, 92 (2), May, pp. 16-21.
- Carneiro, Dionisio D. and Rogério L. Werneck (1993), “Obstacles to investment resumption in Brazil”, in: Edmar L. Bacha (ed.), *Savings and Investment Requirements for the Resumption of Growth in Latin America*, Johns Hopkins University Press.
- Cole, Harold L. and Lee E. Ohanian (1999), “The Great Depression in the United States from a neoclassical perspective”, *Federal Reserve Bank of Minneapolis Quarterly Review*, 23 (1), pp. 2-24.
- \_\_\_\_\_. (2002), “The Great U.K. Depression: a puzzle and possible resolution”, *Review of Economic Dynamics*, 5 (1), pp. 19-44.
- Cooley, Thomas F. and Edward C. Prescott (1995), “Economic growth and business cycles”, In: Thomas F. Cooley (ed.), *Frontiers of Business Cycle Research*, Princeton, Princeton University Press.
- Fisher, Jonas D.M. and Andreas Hornstein (2002), “The role of real wages, productivity, and fiscal policy in Germany’s Great Depression 1928-37 ”, *Review of Economic Dynamics*, 5 (1), pp. 100-127.
- Gollin, Douglas (2002), “Getting income shares right”, *Journal of Political Economy*, 110 (2), pp. 458-474.
- Hansen, Gary D. (1985), “Indivisible labor and the business cycle”, *Journal of Monetary Economics*, 16, pp. 309-327.
- Hayashi, Fumio and Edward C. Prescott (2002), “The 1990s in Japan: a lost decade”, *Review of Economic Dynamics*, 5 (1), pp. 206-235.
- Kehoe, Timothy J. and Edward C. Prescott (2002), “Great Depressions of the Twentieth Century”, *Review of Economic Dynamics*, 5 (1), pp. 1-18.
- Kydland, Finn E. and Carlos E.J.M. Zarazaga (2002), “Argentina’s Lost Decade”, *Review of Economic Dynamics*, 5 (1), pp. 152-165.

Parente, Stephen and Edward C. Prescott (2000), *Barriers to Riches*, Cambridge, MIT Press.

Prescott, Edward C. (1999), "Some observations on the Great Depression", *Federal Reserve Bank of Minneapolis Quarterly Review*, 23 (1), pp. 25-31.

\_\_\_\_\_. (2002), "Prosperity and depression", 92 (2), *American Economic Review*, May, pp. 1-15.

Young, Alwyn (1995), "The tyranny of numbers: confronting the statistical realities of the East Asian growth experience", *Quarterly Journal of Economics*, 110 (3), August, pp. 641-680.

## Data Appendix

This appendix first presents a short analysis about the reliability of the Brazilian data according to the Penn World Table rating. Second it describes the raw series as well as the constructed series used in the paper.

### Reliability of Brazilian data

The Penn World Table (PWT) provides a rating of the reliability of its estimates. According to Summers, Heston and Aten (1991, 2002), this rating is based on three factors. First, the number of times a given country had been used in the benchmark studies carried out by the United Nations in 1970, 1975, 1980 and 1985. Second the income level of those benchmark countries. The lower the income level the greater the variance among the estimates. Third, the limitation of available data for nonbenchmark countries. Following these parameters, the classification of the Brazilian data in PWT Mark 5 was **C** – in a A to D scale (see Summer and Heston, 1991). In the forthcoming PWT Mark 6, the classification of the Brazilian data continues to be **C**.

Table 1 shows the Brazilian classification in PWT6 and of others Latin American countries. As we can see, the Brazilian data is rating like the Mexican data. Argentina, Chile and Uruguay appear in a better position, with grade B. For example, Brazil is closer to Argentina and Chile than Venezuela and Trinidad & Tobago.<sup>14</sup> For our purpose, the main index of data quality is the variance between estimates, column (a), and the data rank, column (c).

---

<sup>14</sup> Trinidad & Tobago is a Caribbean country and its grade is C, but the variance is 2, benchmark is 2 and data rank is 3.

Table 1 – Comparative grades between Brazil and others Latin American countries

	Grade	(a) Variance	(b) Benchmark	(c) Data rank
Brazil	C	4	2	3
Argentina	B	5	2	3
Chile	B	5	2	3
Mexico	C	4	2	3
Venezuela	C	3	2	2
Uruguay	B	5	2	3

Besides the quality evaluation of the Brazilian data carried on by the PWT, we will give a brief description of the procedures used by the Brazilian National Accounting System. At first, the Getulio Vargas Foundation computed the Brazilian data and, since 1987 it has being computed by IBGE (Brazilian Institute of Geography and Statistics).

Brazil started its national account system in 1946, computed by the Getulio Vargas Foundation, using the procedures suggested by the United Nations. In 1970, IBGE started many new surveys to support and update the Brazilian National Account System: Annual National Household Survey (PNAD), Annual Industrial Survey (PIA) and sectorial census (agriculture, industry and services). During the 1980s, new surveys were introduced to compute employment and output level (Monthly Employment Survey and Monthly Output Survey). In 1980 IBGE incorporated the SNA Rev 3 standard in order to improve the quality of the data. In 1997 IBGE started using the System for National Account SNA-93, recalculating back the series from 1990.

The availability of officialy revised series only up to 1998 set the time span considered for the present study.

## Series

### Raw series

1. Nominal Gross National Product, 1947-1998  
IBGE

### Source

Nt.Ac.,

2. Nominal Private Consumption, 1947-1998 IBGE	Nt.Ac.,
3. Nominal Government Consumption, 1947-1998 IBGE	Nt.Ac.,
4. Nominal Gross Fixed Capital Formation, 1947-1998 IBGE	Nt.Ac.,
5. Nominal Inventory Changes, 1947-1987: 1990-1998 IBGE	Nt.Ac.,
6. Nominal Gross Fixed Capital Formation, Construction, 1947-1998 IBGE	Nt.Ac.,
7. Nominal Gross Fixed Cap. Form, Machinery and Equipment, 1947-1998 Nt.Ac., IBGE	
8. Nominal Private Gross Fixed Capital Formation, 1970-1998 IBGE	Nt.Ac.,
9. Nominal Government Gross Fixed Capital Formation, 1970-1998 IBGE	Nt.Ac.,
10. Nominal Exports, 1947-1998 IBGE	Nt.Ac.,
11. Nominal Imports, 1947-1998 IBGE	Nt.Ac.,
12. Implicit deflator of GDP IBGE	Nt.Ac.,
13. Brazilian per capita GDP relative to USA, 1950-1998 Table 6	Penn World
14. Industrial capacity utilization (%), 1970-1998	FGV
15. Tax share on GDP (%), 1947-2001 IBGE	Nt.Ac.,
16. IPA-DI, general, 1970-2000 (1998 = 100)	FGV
17. IPA-DI, machines, vehicles, and equipment, 1970-2000 (1998 = 100) FGV	
18. IPA-DI, construction equipment, 1970-2000 (1998 = 100)	FGV
19. IPA-DI, consumption – durables, 1970-2000 (1998=100)	FGV
20. IPA-DI, consumption – non durables, 1970-2000 (1998=100)	FGV

Notes:

- (a) IBGE denotes the Brazilian Institute for Geography and Statistics (Instituto Brasileiro de Geografia e Estatística).

- (b) Nt.Ac., IBGE, denotes the National Accounts Statistics published by IBGE.
- (c) IPEA denotes the Institute for Applied Economic Research (Instituto de Pesquisa Econômica e Aplicada), Ministry of Planning, Brazilian Federal Government.
- (d) Nt.Cn., IBGE, refers to the Brazilian National Census conducted by IBGE every 10 years approximately: 1950, 1960, 1970, 1980 and 1991.
- (e) FGV refers to Fundação Getúlio Vargas.
- (f) PNAD, IBGE (Pesquisa Nacional de Amostragem Domiciliar) refers to the Brazilian Households National Survey conducted by IBGE, for the period 1970-1998 but 1974, 1975, 1991 and 1994.
- (g) Pop.Acc., IBGE (Contagem da População) refers to the statistics obtained by IBGE in 1996 regarding the structure and characteristics of the Brazilian population.

### **Description of key raw series**

1. *Gross Fixed Capital Formation (1947-1998)*: composed by investments in three categories, namely *building construction*, *machine* and *others*. The item *machine* is computed as the total volume invested in machineries, including transportation and installation, of all machineries produced in Brazil minus the export of those capital products plus the total value of imported machineries. The item *others* include investment in planted forests, new permanent cultures and the value of breeding animals.
2. *IPA-DI*: wholesale price index covering the entire economy (general) and specific sectors of manufactures (machines, vehicles, and equipment; and construction equipment).

### **List of constructed series**

- C1. Real Gross National Product, 1947 – 1998 (thousands of 1998 Reais)
- C2. Real Private Consumption, 1947 – 1998 (thousands of 1998 Reais)
- C3. Real Consumption of Durables Goods, 1970 – 1998 (thousands of 1998 Reais)
- C4. Real Consumption of Non-Durables Goods, 1970 – 1998 (thousands of 1998 Reais)
- C5. Real Government Consumption, 1947 – 1998 (thousands of 1998 Reais)
- C6. Real Gross Fixed Capital Formation, 1947 – 1998 (thousands of 1998 Reais)
- C7. Real Gross Fixed Capital Formation, Construction, 1947-1998
- C8. Real Gross Fixed Capital Formation, Machinery and Equipment, 1947-1998
- C9. Real Inventories Changes, 1947-1998 (thousands of 1998 Reais)
- C10. Real Private Gross Fixed Capital Formation, 1970 – 1998 (thousands of 1998 Reais)
- C11. Real Government Gross Fixed capital Formation, 1970 – 1998 (thousands of 1998 Reais)
- C12. Real Exports, 1947 – 1998 (thousands of 1998 Reais)
- C13. Real Imports, 1947 – 1998 (thousands of 1998 Reais)
- C14. Price Index, 1947 – 1998 (base year: 1998)

- C15. Real Capital Stock, 1970 – 1998 (thousands of 1998 Reais)
- C16. Working age population, 10 – 69, 1950 – 1998
- C17. Economically Active Population, 1950-1998
- C18. Employment, 1950 – 1998
- C19. Average weekly worked hours, 1970 – 1998
- C20. Hours worked, 1970 – 1998
- C21. Total factor productivity, 1970 – 1998

### **Construction of the series used in the paper**

1. To transform the nominal series into real series we used the GDP implicit deflator to construct a price index taking 1998 as the base-year. While this method does not account for changes in relative prices due to the Brazilian hyperinflation (late 1980s), the use of a single price index keeps the consistence between the various components of the national expenditure. Unless one can use an implicit deflator for each series, this consistency would be compromised by the use of a different price index for each series.

2. *Real Consumption of Durable Goods and Non-durables (1970 – 1998)*: The Brazilian National Account System provides information about the final consumption of goods classified by sector of activity for 1970, 1975, 1980, 1985 and 1990. The consumption of non-durable goods for these years is calculated as the sum of the demand for final consumption of each sector classified as a producer of a non-durable good. Following the adopted methodology, the share of non-durable consumption in total consumption was computed for each of those years. Then a linear interpolation of these shares was made in order to determine the share of non-durable consumption for the missing years between 1970 and 1990. To calculate the consumption of non-durable goods in the years with missing data the share calculated above is multiplied by the total consumption. The result is added to a random variable. The random variable is calculated so that the relative volatility of the generated data matches the relative volatility of the actual data. For the period 1990-1998 the necessary information is directly available in the New National Account System (SNA-93).

3. *Capital Stock (1970-1998)*: capital stock series ( $K_t$ ) were computed using the Perpetual Inventory method. Gross Fixed Capital Formation ( $GFCF_t$ ) consists of three components, namely investments in construction structures ( $S_t$ ), machineries and equipments ( $ME_t$ ), and others ( $O_t$ ). Gross Capital Formation ( $GCF_t$ ) is in turn obtained

adding the inventory changes ( $IC_t$ ). Total investment flow is then computed including to this gross capital formation the consumption of durable goods ( $CD_t$ ). The depreciation rate was taken as  $\delta_{ME}=15\%$  for capital stock of machineries and equipments ( $KME_t$ ) and  $\delta_{KS}=3.5\%$  for capital stock of structures ( $KS_t$ ) taken from the WPN, whereas the depreciation rate for other capital stock ( $KO_t$ ) was taken as  $\delta_{KO}=15\%$  as well. i.e.

$$K_{t+1} = GFCF_t + IC_t + CD_t + (1 - \delta_{ME})KME_t + (1 - \delta_{KS})KS_t + (1 - \delta_{KO})KO_t$$

To compute the initial capital stock  $K_{1970}$ , the capital labor ratio computed by IPEA  $(K/Y)_{1970}=1.33$  was used. Therefore,  $K_{1970} = 1.33 Y_{1970}$ .

4. *Working-age population (1950-1998)*: the 10 to 69 years-old population was taken as the Brazilian working-age population instead of the commonly used interval 15-64 due to the existence of child labor as well as the limited social security coverage in the country. The National Census data for 1950, 1960, 1970, 1980 and 1991 and the Population Account of 1996 were taken and linear interpolation techniques were applied in order to obtain the series up to 1996. The average growth rate of this working-age population for the period 1991-1996 was taken in turn to linearly project the corresponding data for 1997 and 1998.

5. *Average weekly worked hours (1970-1998)*: the Brazilian National Census data and the PNAD data, both published by IBGE, were used to compute this series. Yet the missing data for 1974, 1975, 1991 and 1994 were supplied by means of a linear interpolation of the series. The raw data presents the weekly worked hours by intervals of hours worked and, also variation of the considered sample of workers. Therefore, these raw data were treated using the methodology proposed by McGrattan and Rogerson (1998) in order to obtain a consistent average value for the average weekly worked hours.

6. *Economically active population (1950-1998)*: The Brazilian census give the data on the economically active population for 1950, 1960, 1970, 1980 and 1991. For the missing years between 1950 and 1970 we used a linear interpolation. For the missing years between 1970 and 1998 we used the values given by the Annual Household Survey (PNAD), except for 1974, 1975, 1992 and 1994. In this years PNAD were not carried on by the government. Again, we used linear interpolation to get the corresponding values.

7. *Employment (1950-1998)*: The Brazilian census estimates the employment for 1950, 1960, 1970 and 1980. Between 1990-1998 employment is computed in the National Account (IBGE). For the missing values between 1950 and 1990 we get employment data using linear interpolation.

8. *Hours Worked (1970-1998)*: (employment) x (average weekly worked hours) x (number of weeks per year).

9. *Total Factor Productivity (1970-1998)*: For computation of total factor productivity we use the Cobb-Douglas production function:  $A = \frac{Y}{K^\theta L^{1-\theta}}$ , where  $Y$  is the GNP per working age person,  $K$  is the capital stock per working age person,  $H$  is the total hours worked,  $A$  is the total factor productivity,  $\theta$  is the capital share and  $t$  is the time subscript. For calibration of  $\theta$  we follows Gollin's (2002) guidelines.

## Detrending

All series were detrended according to the expression below.

$$y_t^d = \frac{y_t}{(1 + g)^{t-1980} \cdot y_{1980}}$$

where  $y_t^d$  denotes the detrended series,  $y_t$  is the undetrended series,  $g$  is the trend, and  $t$  is the time period, for  $t = \{1980, \dots, 1998\}$ .

## Data for growth accounting

The data for growth accounting are the capital input, the labor input, the total factor productivity and the Gross National Product. The capital input ( $K$ ) corresponds to the Capital Stock (C13); the labor input ( $L$ ) is the product between the total employment (C18) and the average weekly worked hours (C19). The total factor productivity ( $A$ ) is calculated as described in the paper, i.e.:  $A = \frac{Y}{K^\theta L^{1-\theta}}$ , where  $Y$  represents the GNP and  $\theta$  the capital share.

## References

[1] Gollin, Douglas (2002), "Getting income shares right", *Journal of Political Economy*, 110 (2), pp. 458-474.

[2] McGrattan, Ellen R. and Richard Rogerson (1998), "Changes in hours worked since 1950", *Federal Reserve Bank of Minneapolis Quarterly Review*, 22 (1), pp. 2-19.

[3] Summers, Robert and Alan Heston (1991), "The Penn World Table (Mark 5): an expanded set of international comparisons, 1950-1988", *Quarterly Journal of Economics*, 106 (2), May, pp. 327-368.

[4] Summers, Robert, Alan Heston and Bettina Aten (2002), Data appendix for a space-time system of national accounts: Penn World Table 6.0 (PWT 6.0). Unpublished document. Available at <http://webhost.bridgew.edu/baten>.

## The ECO/UnB Working Paper Series

The Department of Economics of the University of Brasilia publishes its Working Papers Series since April 1972. On August 30, 2002 the series was renewed with the on-line publication of the papers. All Working Papers may be freely downloaded from the Department site: <http://www.unb.br/ih/eco>.

Working papers published since August 2002:

- 231 Posse de escravos e estrutura da riqueza no agreste e sertão de Pernambuco: 1777-1887. Flávio Rabelo Versiani and José Raimundo O. Vergolino, 30 August 2002, 29p.
- 232 On the natural rates of unemployment and interest: the Robertson connection. Mauro Boianovsky and John R. Presley, 30 August 2002, 34p.
- 233 Contas Nacionais e o meio ambiente: reflexões em torno de uma abordagem para o Brasil. Charles C. Mueller, 30 August 2002, 25p.
- 234 Economics of air pollution: hedonic price model and smell consequences of sewage treatment plants in urban areas. Sérgio A. Batalhone, Jorge M. Nogueira and Bernardo P. M. Mueller, 30 August 2002, 25p.
- 235 The Brazilian depression of the 80s and 90s. Mirta Bugarin, Roberto de G. Ellery Jr., Victor Gomes and Arilton Teixeira, 30 August 2002, 30p.
- 236 Informal employment in Brazil – A choice at the top and segmentation at the bottom: a quantile regression approach. Maria Tannuri-Pianto and Donald M. Pianto, 30 August 2002, 23p.
- 237 False contagion and false convergence clubs in stochastic growth theory. Stephen de Castro and Flávio Gonçalves, 30 August 2002, 20p.
- 238 Spot and contract markets in the Brazilian wholesale energy market. Paulo C. Coutinho and André Rossi de Oliveira, 30 August 2002, 19p.
- 239 Tributação da renda e do consumo no Brasil: uma abordagem macroeconômica. Valter Borges de Araújo Neto e Maria da C. S. de Sousa, 6 September 2002, 31p.
- 240 Vote splitting, reelection and electoral control: towards a unified model. Maurício S. Bugarin. 30 August 2002, 26p.

Forthcoming working papers:  
(Subject to change)

- 241 Shadow-prices in payment systems. Rodrigo Peñaloza, 30 August 2002, 30p.
- 242 Welfare implications of the Brazilian social security system. Roberto de G. Ellery Jr. and Mirta N. S. Bugarin, 13 September 2002, 28p.
- 243 Os agentes econômicos em processo de integração regional – Inferências para avaliar de efeitos da ALCA. Renato Baumann and Francisco Galvão Carneiro, 20 September 2002, 33p.
- 244 Leading by example: a simple evolutionary approach. André Rossi de Oliveira and João R. O. de Faria, 27 September 2002, 24p.
- 245 The role of institutions in sustainable development. Bernardo Mueller and Charles Mueller, 4 October 2002, 23p.
- 246 Consórcios intermunicipais de saúde: uma análise à luz da teoria dos jogos. Luciana Teixeira, Maria Cristina MacDowell and Mauricio Bugarin, 11 October 2002, 30p.

- 247 Liquidity constraints and the behavior of aggregate consumption over the Brazilian business cycle. Mirta Bugarin and Roberto de G. Ellery Jr, 18 October 2002, 19p.
- 248 Pricing water and sewage services in urban areas: Evidences of low level equilibrium in a developing economy. Ricardo Coelho de Faria, Jorge M. Nogueira and Bernardo Mueller, 25 October 2002.
- 249 Wrong incentives for growth in the transition from modern slavery to labor markets: Babilon before, Babilon after. Stephen de Castro, 1 November 2002, 23p.
- 250 Vintage capital, distortions and development. Samuel Pessoa and Rafael Rob, 8 November 2002, 40p.
- 251 A note on Armstrong's optimality of exclusion property. Mauricio Bugarin, 15 November 2002, 20p.
- 252 Preços de escravos em Pernambuco no século XIX. Flávio R. Versiani and José Raimundo O. Vergolino, 22 November 2002, 20p.
- 253 A model of capital accumulation and rent seeking. Paulo Barelli and Samuel de Abreu Pessoa, 29 November 2002, 40p.
- 254 Anchors away: the cost and benefits of Brazil's devaluation. Edmund Amann and Werner Baer, 6 December 2002, 19p.