ACCOUNTING FOR BRAZIL'S LONG TERM GROWTH[*]

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Summary

The paper aims at explaining why Brazil's GDP growth plunged after 1980. Brazil's GDP grew at 7% yearly from 1940 to 1980 but at only 2.5% per year since then. Increases in the relative price of investment that reduced the purchasing power of savings, associated to declines in the productivity of capital, seem to have been the most important factors behind the observed loss of dynamism. The tentative conclusion is that inward-oriented economic policies since the 1970s and, perhaps, even as early as the 1950s, had negative long-run growth implications that were aggravated by populist policies in the early years of the post-1984 redemocratization.

Key Words: Economic Growth, Capital Accumulation, Savings, Relative Price of Investment, Productivity of Capital

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(1) Introduction

A mystery surrounds Brazil's long-term growth experience. Why is it that this country's GDP growth collapsed since 1980 after expanding at some 7% per year from 1940 through 1980? Brazil's economic growth plunge is summarized in Figure 1 that exhibits yearly GDP growth rates from 1940 through 2002. A ten-year trend line is superimposed to illustrate the sharp downswing of the country's growth rate since 1980.

[Figure 1: GDP growth rates, 1940-02]

[All figures and tables are at the end of the paper]

This paper is part of a recent surge of interest in the analysis of Brazil's growth experience, as illustrated by Bonelli and Fonseca (1998), Pinheiro et al. (2001), Bugarin et al. (2003), Pinheiro (2003), and Gomes, Pessoa and Veloso (2003). Its distinguishing feature is a novel way of expressing the equality between savings and investment as an organizing device to account for Brazil's growth. Section 2 provides a historical sketch of Brazil's growth experience embedding the findings of the paper. The empirical analysis starts in section 3 that exhibits the association between GDP growth and capital accumulation predicted by the two standard growth models in the literature. Section 4 presents a new way of decomposing the savings-investment identity to account for the multiple components of capital accumulation. Section 5 shows that savings, by themselves, are not sufficient to explain the collapse of Brazil's capital formation and GDP growth. Sections 6, 7, and 8 argue that, for a fuller description of capital accumulation, account needs to be taken, in addition to savings, of changes in the relative price of investment, output to capital-in-use ratio, and capacity utilization rate. Section 9 proposes a taxonomy of Brazil's growth phases since the 1940s and discusses alternative decompositions of capital stock and GDP growth for these phases, indicating *inter alia* the factors accounting for the collapse of economic growth since 1980. Section 10 concludes with estimates of Brazil's current growth potential. Appendix 1 briefly reviews the 'Y=AK' and Solow-Swan growth models used in the paper and Appendix 2 details the procedures to estimate the degree of capacity utilization.

(2) Historical Sketch

Unveiling the mystery of post-1980 Brazil's growth slump requires going back to the early 1970s, perhaps the early 1950s. On both occasions, the country was hit by long-lasting adverse terms of trade shocks: an oil shock in one case, a coffee price slump in the other. The policy responses to the resulting foreign exchange scarcity could have mimicked those of the Southeast Asian countries, and focused on increasing the 'exportability' of the economy—thus reducing the country's dependency on coffee exports in the 1950s, and reinforcing its capacity to pay for dearer oil imports in the 1970s. Export pessimism associated with the lobbying interests of coffee growers and inward-oriented industrialists prevented this from happening in the early 1950s. Instead, coffee valorization and industrial protectionism maintained the country's dependency on coffee exports while generating a major import substitution industrialization (ISI) drive.

The period from 1952 to 1955 was critical in the definition of the industrialization pattern that Brazil followed henceforth. In 1952, President Vargas (1/51-8/54), under the prodding of finance minister Horacio Lafer (2/51-6/53), reinstated the pre-war coffee valorization policy as a means of defending an exchange rate that had become overvalued when the Korean War boom ended. In 1953, finance minister Oswaldo Aranha (6/53-8/54) instituted a multiple exchange rate system as a means of privileging 'essential' imports—defined as those without competitive domestic production. To support the industrialization drive, a national development bank (BNDE) was created in 1952 and a national oil company (Petrobras) instituted in 1953. Conservative President Café Filho (8/54-11/55) took over after Vargas's suicide in August 1954. Finance minister Eugenio Gudin (8/54-4/55) attempted to undo the coffee valorization scheme but was forced to resign. His successor, José Maria Whitaker (4/55-10/55), tried to dismantle Aranha's multiple exchange rate system, only to be fired as well. President Café Filho himself was overthrown in the so-called democratic anti-coup of November 1955. With the election of President Juscelino Kubitschek (1956-60), the game was over and Brazil embarked on a path of import substitution industrialization that was to last until the 1980s. The seeds of economic inefficiency were thus introduced into the Brazilian economy, in the form of an increasing cost of investment goods and a declining productivity of capital. A caveat, however applies: more capital-intensive production processes were adopted worldwide in response to the oil shocks of the early 1970s, as a consequence of which the productivity of capital decreased in the world as a whole, albeit not as much as in Brazil. Peculiar to Brazil was the association of this decline with a sharp rise in investment goods prices.

Industrial protectionism under President Kubitschek came in association with the promotion of foreign direct investment. This increased the rate of absorption of technical progress and succeeded in maintaining the growth impulse inherited from the 1940s. Political convulsion associated with accelerating inflation in the early 1960s temporarily interrupted this process. The technocrats coming to power with the military coup of 1964 managed to stabilize the economy, while introducing major tax and financial reforms and maintaining a friendly attitude towards foreign capital. The resulting saving and investment boom, associated to a high rate of technical progress, became known as the 'Brazilian economic miracle' of the 1964-74 period. An overextended economy was hit by the oil shock of the early 1970s. The obsession to legitimize through short-term economic success a statist authoritarian regime determined a renewed emphasis on heavy ISI, financed by sharp external debt accumulation. The critical turning point defining Brazil's economic future was general Geisel's (03/1974-03/1979) decision to fight the 1973 oil shock by doubling the bet on extra-heavy import substitution. This could be put into effect only through deep reliance on the international financial recycling of the petrodollars. With the benefit of hindsight, this was an unfortunate course of action, as the international scene deteriorated continuously from the late 1970s onward. In the domestic economy, increased wage indexation accompanied the opening up of the military regime that was initiated by the same general Geisel and carried out by general Figueiredo (03/1979-03/1985). Excess domestic demand and wage and price indexation led the external debt and domestic inflation to increase sharply. The relative price of investment increased and the productivity of capital declined substantially between 1974 and 1984. This period was also characterized by technical 'regress' rather than technical progress. Continued international adversity eventually forced the country into a default on its external obligations in late 1982.

The financial crisis of the early 1980s put an end both to the military regime and Brazil's growth splurge. The country's return to democracy in 1985 occurred under a heavy debt burden and accelerating inflation. The political euphoria with redemocratization, catapulted by the short-term success of a wage and price freeze in 1986, obscured the economic inefficiencies inherited from the military regime. This fed into a sequence of failed 'heterodox' stabilization experiments and debt defaults, while a new populist Constitution was promulgated in 1988—thus making the country nearly ungovernable. The debt defaults started in earnest when finance minister Delfim Netto (1967-74 and 1979-84) sharply underestimated the domestic debt 'inflation adjustment factor' in 1980. (Brazil's domestic debt was typically issued as a fixed-rate note placed at a discount over face and carrying an 'inflation adjustment factor' to compensate the debt-holder for increases in the general price index.) There followed the same minister's external debt restructuring in December 1982. Next in line, President Sarney (1985-89) implemented three successive 'heterodox stabilization shocks' that temporarily suppressed the 'inflation adjustment factor' on domestic debt. In early 1987, Sarney defaulted on external public debt. The biggest domestic debt default of all was the freezing for one year of nearly all domestic financial assets at the start of the Collor government (01/1990-09/92).

Hyperinflation broke out but was eventually dominated by the Real Plan in 1994. This opened the way under President Cardoso (01/1995-12/2002) for a radical departure from the statist ISI model that prevailed under the military. But a lax fiscal stance and excessive reliance on a dollar anchor (which required the support of high real interest rates) crowded out exports and private investment, thus preventing a sustained economic recovery from taking place. A more sensible macroeconomic policy tripod was put into place after a foreign exchange crisis that culminated with a maxi-devaluation in early 1999: a large primary fiscal surplus, an inflation targeting monetary policy, and a floating exchange rate. The structural reforms of the Cardoso government managed to stop the long-term processes of increasing cost of investment and declining productivity of capital, while raising capacity utilization without rekindling inflation. Technical progress resumed, probably as a consequence of import deepening and privatization, but this was not sufficient to generate sustained growth, even after 1999, because capital accumulation was held back by a succession of adverse shocks: the blow-up of the Nasdaq bubble, domestic energy crisis, September 11, Argentine's default, and the specter of a left-wing Lula presidency. In his first years in government, instead of attempting a populist return to the 'statist' closed economy model of the past—as many have feared—President Lula maintained intact the post-1999 macroeconomic policy tripod. He also continued to reform the unwieldy legal edifice that was erected by the

1988 Constitution. The economy recovered, but sustained growth resumption is still a question mark.

The following sections develop a growth-accounting framework to substantiate the interpretations in this sketch and permit an appraisal of Brazil's current growth potential.

(3) GDP Growth Correlates with Capital Accumulation

A natural candidate to start an explanation of Brazil's growth is capital accumulation. In the so-called Y = AK model, capital accumulation is the only factor responsible for GDP growth. In a Solow-Swan world, capital accumulation shares this responsibility with effective labor, along an adjustment process towards a possibly moving steady state. Appendix 1 provides a brief review of the 'Y=AK' and the Solow-Swan models. Using the Penn World Tables data set, Bernanke and Gürkaynak (2001) found that the implication of a simple AK model, that country growth rates depend on the saving rate ('proxied' by the real investment rate), was more consistent with the data than the Solow-Swan model steady-state result that growth is exogenous. The 'reduced form' of the AK model is the same as the traditional Harrod-Domar growth model.

The presumption that GDP growth correlates with capital accumulation finds comfort in the Brazilian data[1].

[Figure 2: GDP and capital stock growth rates, 1941-2002]

Figure 2 graphs the yearly growth rates of the capital stock along with those of GDP. A positive association is apparent between the two series. In particular, the GDP

[1] The Brazilian system of national accounts starts in 1947. Data for previous years are available but with varying quality, especially in what concerns price deflators. Lucilene Morandi graciously provided us with the national income data for 1940 through 1946, as well as with the capital stock series. This was built by her on the basis of a perpetual inventory method, consistently with the real investment series in Brazil's national accounts. For details, see Morandi and Reis (forthcoming).

growth slump since 1980 is accompanied by a similar collapse of real capital formation. Trend GDP is thus well captured by the evolution of the capital stock, but Figure 2 also indicates that the yearly growth rate of GDP is much more volatile than that of the capital stock. This is as expected in view of the cyclical and irregular components of the GDP series as well as the inertia associated with changes in the relationship between investment flows and capital stocks. The concept of capital-in-use is introduced to allow for these fluctuations. This is obtained by multiplying the capital stock by the degree of capacity utilization calculated as explained in Appendix 2. The correlation between GDP growth and the growth rate of capital-in-use turns out to be very high (R=0.83). This confirms that capital accumulation is indeed a good starting point for an analysis of GDP growth. Keeping in mind that later we will have to incorporate labor employment and technical progress into the analysis, we begin the discussion of Brazil's growth focusing on the determinants of the capital stock growth rate.

(4) Fully Accounting for Capital Accumulation

Our departure point is the expression:

$$K' = I/K - \delta \qquad (1)$$

where K' is the capital stock growth rate; I, gross real investment; K, the capital stock in place; and δ the depreciation rate.

The ratio of gross real investment to capital stock (I/K) can be written as the product of gross real investment rate by the output to capital ratio:

$$I/K = (I/Y).(Y/K) \qquad (2)$$

The gross real investment rate (I/Y), in turn, is identically equal to the product of the (nominal) saving rate by the inverse of the relative price of investment:

$$I/Y = (P_iI/P_yY).(P_y/P_i) = (S/P_yY).(P_y/P_i) = s.(1/p), \qquad (3)$$

where the first equality is just an expedient to introduce the nominal investment rate (P_iI/P_yY), and thus make use of the equality between nominal savings and nominal investment in the second equality. (Only recently did inventory changes begin to be calculated in Brazil's national accounts. For most of the series such inventory changes are incorporated into private consumption. For this reason, for the whole series we defined gross savings to be equal to nominal gross fixed investment. In Brazil's national accounts, savings continue to be estimated as a residual, hence the equality between savings and investment holds without any statistical discrepancy.) The third equality is merely a consequence of the definitions of $s = S/P_yY$ and $p = P_i / P_y$.

The output to capital ratio (Y/K) can be written as the product of the capacity utilization rate, u, by the ratio of output to capital-in-use, v:

$$Y/K = u.(Y/uK) = u.v \qquad (4)$$

Substituting (3) and (4) into (2) and the result in (1), we finally obtain:

$$K' = s.(1/p).u.v - \delta \qquad (5)$$

Equation (5) shows that the impact of the saving rate (s) on the capital stock growth rate (K') is conditioned on the relative price of investment (p), the capacity utilization rate (u), and the output to capital-in-use ratio (v). The depreciation rate (δ) needs also to be taken into account–except for the fact that, as it varies only between 0.038 and 0.040 in the series we use, it does not contribute to explain changes in capital accumulation through time.

Table 1 shows the correlations between the series for GDP growth Y' and those for K', v, u, p, and s in 1941-2002 and 1952-2002 (this second period is selected because, as we argued in section 2, 1952 was a critical turning point in Brazil's growth experience). The correlation coefficient between Y' and K' is 0.52 in 1941-02 and 0.60 in 1952-02. In both periods, the degree of capacity utilization, u, is the variable with the closest association with the yearly GDP growth rate (R = 0.70 and 0.74, respectively in 1941-02 and 1952-02). Next in line are the correlations of Y' with the relative price of investment, p (R = -0.53 and -0.59, respectively), and with the output to capital-in-use ratio, v (R = 0.37 and 0.59, respectively). Surprisingly, the saving rate s is negatively correlated (albeit not significantly in some cases) with all growth-related variables. Interestingly enough, p and v are among the variables with the closest interrelationship in the statistical series (R = -0.68 in 1941-02 and a whopping -0.92 in 1952-02), followed by those between K' and p. The next sections try to decipher the implications of such associations for the historical behavior of the capital stock growth rate.

[Table 1 enters here]

(5) Savings Alone do not Explain the Growth Slump

Savings should be an obvious candidate to explain the collapse of capital accumulation since 1980. Figure 3 exhibits the behavior of both total (domestic plus foreign) and domestic saving rates (gross savings over nominal GDP), from 1940-2002. Domestic savings are obtained as a residual from total savings after deduction of foreign savings, the calculation of which may vary through time. We will privilege an analysis based on total (domestic + foreign) savings and broadly ignore the series for domestic savings.

[Figure 3: Saving rates, 1940-2002]

With little fluctuation, the total saving rate averages some 15% of GDP from 1947 through 1965. It escalates to near 24% in 1980, and then sinks to some 19% henceforth—with an incredible spike during the hyperinflationary 1987-89 period, when it averaged 24.8%. The deviant behavior of the domestic saving rate in 1987-89 seems at odds with the economic realities of this turbulent period: a time during which government savings contracted and inflation accelerated. It is difficult to believe that under such circumstances the domestic saving rate would have increased to 27% of GDP in 1989 from the relatively stable 19% observed from 1970 through 1986, only to fall back to the same relatively stable 19% in the following 1990-93 period! An error of measurement of nominal savings in 1987-89 is suggested by this behavior. Testing this hypothesis would require a detailed evaluation of the price series underlying the current price national accounts of the period. For the time being we will accept the series for savings as they appear in the national accounts.

The movements of the saving rate are sharp, but bear little relation to the slump of capital formation after 1980. This lack of association is documented by a non-significant correlation coefficient of R = -0.02 between capital stock growth and the total saving rate for the 1941-2002 period.

On closer inspection of the data, however, a structural break seems to have occurred since the early 1980s in the relationship between the saving rate and the capital stock growth rate: correlation coefficients of 0.66 and 0.64 between capital stock growth and the total saving rate were found for the 1941-1980 and 1981-2002 periods, respectively. This indicates that some association exists. But the same saving rate seems to generate less capital stock growth after 1980 than before.

Thus, the apparent lack of relation between capital accumulation and the saving rate for the period as a whole does not mean that the saving rate does not matter for capital accumulation; only that savings, by themselves, cannot explain Brazil's growth plunge since 1980. The following sections investigate which variables might be clogging the transmission mechanism from savings to capital accumulation and GDP growth in Brazil since 1980.

(6) Sustained Increase in the Relative Price of Investment

Figure 4 displays the extraordinary behavior in 1950-2000 of the relative price of investment, defined as the ratio between the price deflator of gross fixed investment and the price deflator of GDP. These data are from the Heston, Summers and Atten (2002) Penn World Tables project (PWT 6.1) and are not exactly the same as those directly derived from the Brazilian national accounts. However, the correlation coefficient between the two relative price series is very high: R = 0.962. In the PWT, the numeraire for all price indices in all years is the US GDP deflator. The same figure displays the evolution in 1950-2000 of a similar variable: the world average for the relative price of investment at international dollar prices, also from the PWT project.

[Figure 4: Relative price of investment: Brazil and world, 1950-2000]

In broad outline, the relative price of investment in Brazil increases rapidly between the early fifties and the mid-sixties. It then drops a little through the mid-1970s. Subsequently, it rises very sharply. In the early 1990s, p is more than twice as high as in the early 1950s[2]. The relative price of machinery and equipment (not shown) replicates the pattern for the relative price of investment, except for wider fluctuations probably

[2] For an early analysis of the behavior of the relative price of investment goods in Brazil, see D. Carneiro and R. Werneck (1993).

associated to changes in the pricing of imported machinery in some periods, due to real exchange rate movements and trade policy changes.

The increase in the relative price of investment is a Brazilian anomaly in a worldwide perspective. The PWT world average for this price ratio remains nearly constant in the 1950-2000 period, as shown in Figure 4. Possible explanations for the rise of the relative price of investment in Brazil include:

(1) increased oligopoly power in industries producing both final and intermediate investment goods (such as cement);

(2) inefficiencies in the capital goods production process, as more and more of previously imported goods are produced domestically;

(3) higher demand for durable goods, including housing, as a shelter against hyperinflation and financial default risks, with reflexes on the relative price of such goods if the supply curve is upward sloping—a hypothesis suggested by Bugarin et al. (2003);

(4) oligopolistic price-makers' defensive pricing behavior in face of government procurement payment delays, in a context of accelerating inflation[3];

(5) price-index measurement error, as suggested by Pinheiro (2003). This would come in the form of an overestimation of the increases of the nominal prices of investment goods particularly during the 1987-89 hyperinflationary period.

Factors (1) and (2) may have operated more forcefully through the early 80s. Factors (3) to (5) may have become important when inflation got out of control since the early 80s. However, the relative price of investment goods did not fall substantially after stabilization in 1994, which suggests that it is either measurement error or relative

[3] The price deflators for investment goods in the Brazilian national accounts are derived from the wholesale price and national construction cost indexes of Vargas Foundation. These are often derived from 'listed' prices obtained from a sample of firms. For durable goods, which are normally sold on credit, such 'listed' prices may have incorporated a premium increasing with both inflation and payment delays in government procurement.

cost (cum market power), and not speculative demand, that explains the post-1980 behavior of this variable. Furthermore, speculative (or precautionary) demand for durable goods should impinge on the prices of capital goods in place, not necessarily on the cost of new investment goods, which are the object of our analysis.

Consideration of the behavior of the output to capital-in-use ratio will help to further our understanding of the evolution of p.

(7) Falling Output to Capital-in-Use Ratio

Figure 5 displays the behavior of the output to capital-in-use ratio, v, in the 1940-2002 period d. The ratio v was obtained by dividing real GDP (at constant 2000 prices), Y, into the real capital stock in use, u.K[4].

[Figure 5: Output-to-capital-in-use ratio, 1940-02]

The striking fact in Figure 5 is the declining trend of v from the immediate post-WW-II to the early 90s. In more detail, starting from a high level of a little over 0.6 in the early 1940s, the output to capital-in-use ratio increases during WW-II and then declines continuously through the mid-fifties to near 0.5. From the mid-1950s to the mid-1970s v fluctuates along a mildly negative trend. The next stage is a sharp contraction of v, starting in 1973 and only pausing in 1983, with v reducing to some 0.36. A minor decrease follows after 1987, until v stabilizes at about 0.34 since the early 90s (average 1992-2002). Such epochs are broadly consistent with Brazil's industrialization experience: light import substitution during the war through the mid-50s, consumer durables import substitution in the late 50s and 60s, heavy import substitution of capital goods and intermediate products from the early 70s through the early 80s.

Three alternative hypotheses are suggested to explain the decline of v:

(i) first, a decline in the output-capital ratio may be expected as an economy moves from a predominantly rural stage (which was Brazil until the 1930s) to escalate into a full industrial economy. This tendency may have been accentuated by specific characteristics of Brazil's industrialization: a heavily protected low-scale import substitution process, accompanied by an oligopolistic pattern of industrialization under the dominance of government-owned firms;

(ii) second, Brazil's experience may be simply reflecting a more general worldwide trend of declining output to capital ratios;

(iii) finally, in a Solow-Swan world, the output to capital ratio is not a technological datum, and may decline because it is converging towards a lower steady-state value, consistently with, for example, a lasting increase in the saving rate.

We consider each of these hypotheses in turn.

7.1 Guilty by association: relative prices increase as productivity falls. Figure 6 reinforces the conjecture that the import substitution path chosen by Brazil from the early 1950s may be behind the observed behavior of the series. This is a scatter diagram, with the output to capital-in-use ratio in the horizontal axis and the relative price of investment in the vertical axis.

[Figure 6: Negative correlation between v and p since 1952]

From the early 1950s, accompanying the decisions spelled out in Section 2 to deepen the import substitution process, the relative price of investment and the output to capital-in-use ratio display a negative correlation, particularly strong after 1973: as one increases, the other falls, all the way through the early 90s.

Brazil is the 'worst offender' in a PWT 6.1 listing of 63 countries with data for 1960-2000 in terms of the combination of relative price of investment increase (p') and

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[4] As previously explained, the capital stock series is from Morandi and Reis (forthcoming); the series for u

positive correlation (R) between the relative price of investment and the capital-output ratio. For Brazil, this pair is (p' = 168.7% and R = 0.90). Runner-ups are Venezuela (p' = 118.5% and R = 0.87), Israel (p' = 111.9% and R = 0.80), Iran (p' = 84.0% and R = 0.51), Greece (p' = 70.4% and R = 0.95), and Singapore (p' = 69.2% and R = 0.94).

To help fix ideas about a possible causation sequence, think of a one-sector open economy initially producing consumption goods for both domestic use and exports, while importing capital goods to expand capacity. Introduce in this economy a (relatively inefficient) capital goods producing sector towards which, at the margin, consumption goods that could be exported are increasingly diverted, in exchange for domestically produced investment goods. As the size of the diversion increases, overall productivity declines, but this can be temporarily masked if the introduction of the capital goods producing sector is accompanied by an extra-saving effort. This indeed seems to have happened in Brazil. As displayed in Figure 3, the total saving rate increased to 20% of GDP in the early 1970s from around 15% in the 1950s, with a big help from foreign savings. Together with a better use of available capacity, this was more than sufficient to produce the 'Brazilian economic miracle' of the earlier part of the military regime (1964 through 1974). In the latter part of the regime, from 1974 through 1984, following on the government's decision to deepen import-substituting industrialization under very adverse international conditions, the output to capital-in-use ratio declined 24%, while in a highly symmetric movement the relative price of investment increased 33%.

7.2 International causation: a worldwide tendency towards increased capital intensity: Figure 7 compares the evolution in the 1950-2000 period of the output-capital ratio in Brazil with an un-weighted average output-capital ratio of a sample of 83 countries[5]. Brazil's output-

is derived in Appendix 2.

[5] Samuel Pessoa gently made available to us his series for the output-to-capital ratio for these 83 countries, based on PWT data (see Gomes et al., 2003). Since these series are not adjusted for the degree of capacity

capital ratio pattern broadly coincides with the world average, which also declined in the post-1970 period, possibly as a reaction to the oil shocks. Moreover, Brazil's ratio is always lower than the world average, except in the 1967-73 period. These results are only suggestive, because the PWT-based capital stock data can only be relied on after 1970[6]. Even so, they indicate that Brazil was not very different from the rest of the world in the historical evolution of the output-capital ratio.

[Figure 7: Output-capital ratios: Brazil and World, 1950-2000]

7.3 *Adjustment towards a Solow-Swan steady state.* One well-known result of the Solow-Swan model is that if the output to capital ratio is not constant, it is converging to its steady-state value. To obtain this value observe that the steady-state capital growth rate, K'_{ss} (as well as that of GDP, Y'_{ss}), is given by:

$$K'_{ss} = A' + N' \tag{6}$$

where A' is the growth rate of labor-augmenting total factor productivity and N' is the growth rate of the labor force. Figure 8 shows our estimated series for N' and for its sum with A'. A' was estimated as the residual in a Cobb-Douglas production function with labor-augmenting technological progress, assuming a value of 0.5 for the elasticity of output with respect to capital in use. The labor force data was extracted from the decadal population Census and interpolated for the remaining years, assuming a constant elasticity (within each decade) with respect to the growth of the capital stock in use.

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utilization, we also used Pessoa's series, based on the PWT data, for the Brazilian case. Thus, strictly speaking, the series shown in Figure 7 are, in the terminology of this paper, not for "v" itself, but rather for "v.u". In addition, Pessoa's data for 1950-59 comprises only 47 countries. We used the ratio between the average output-capital ratio of this sample to that of the complete sample in 1960 to correct the 1950-59 data and thus prevent the series from jumping when the complete sample was introduced in 1960.

[6] Gomes et al. (2003) used a simulated capital stock value for 1950 (or 1960, depending on the country) and then completed the series applying a perpetual inventory method to the constant-price PWT investment data from then onwards.

[Figure 8: Steady State values of $Y'_{ss} = K'_{ss} = A' + N'$]

The behavior of A' is highly congruent with the volatile pattern of GDP growth. Because of this year-to-year volatility, we will work with annual averages of A' for representative periods, when discussing Brazil's characteristic growth epochs. Broadly speaking, two long waves are suggested from the figure: one previous to the mid-1970s—when A' was generally very high—and another after the mid-1970s—when A' was generally very low. More recently, that is, since 1988, A' seems to be trending upward. Figure 8 suggests that, from the perspective of total factor productivity, the slump in Brazil's growth started not in the 1980s but in the 1970s. We will elaborate on this hypothesis in the next section.

The steady-state value v_{ss} is now easy to calculate. Simply replace the steady-state value of K', given in (6), in the expression for capital accumulation (5), to obtain:

$$v_{ss} = (\delta + A' + N')/s.(1/p).u \quad (7)$$

Putting together the estimates for s(1/p)u and A´+ N´ (plus δ), we calculate the values of v_{ss} that are shown in Figure 9, together with the observed value of v.

[Figure 9: Steady state and observed values of v]

Contrary to conventional textbook wisdom, v_{ss} is not a constant but fluctuates widely. However, the calculated v_{ss} are lower than observed v for most of the period. Hence, a long-term adjustment process towards a lower steady state value might also explain the downward trend of v. This presumption from the Solow-Swan model is confirmed by a simple OLS regression of v on v_{ss} and its own past value summarized in Table 2 below.

[Table 2 enters here]

The coefficients of v(-1) and v_{ss} add up to one, as expected from a process of adjustment in which v converges asymptotically to v_{ss} [7]. In addition, and very importantly, the coefficient of v_{ss} indicates that only 3.6% of the distance between v and v_{ss} is covered in a single year. This means that it takes nearly 19 years to close one half of the gap between observed v and its corresponding steady state value. This result is similar to the numerical simulations of the speed of convergence of a linearized numerical Solow model, in P. Romer (2001). In his simulations, Romer estimates that only 4% of the distance between the observed and the steady state value of the capital to effective labor ratio is covered in a single year.

Our tentative conclusion is that any of the three hypotheses—inefficiencies in the import substitution process, a world-wide trend towards increased capital intensity, and a long-run adjustment to a higher saving ratio—are plausible interpretations for the decline in the output-capital ratio.

(8) Hysteresis of Idle Capacity?

The last component of our explanation for the demise of Brazil's growth is a decline in the average degree of capacity utilization, u. The construction of a series for this variable is not an easy statistical endeavor, particularly because no information on it is available previously to 1968; since then, an inference can be made on the value of economy-wide capacity utilization based on observed capacity utilization rates in the industrial sector. Appendix 2 provides details on the methods we adopted. Figure 10 below shows the behavior of the estimated degree of economy-wide idle capacity, 1-u, from 1940 through 2002. 'Normal' cyclical patterns are depicted through the late 1970s. But, from the early

[7] The residuals of this equation are stationary but not white noise. Other specifications with a constant term added or differenced variables indicate that the estimated coefficients are robust.

1980s on, the Brazilian economy seems unable, even temporarily, to return to a state of full capacity utilization.

[Figure 10: Idle capacity, 1940-02]

Over the 40 years previous to 1980 the average degree of idle capacity was 3.4%. After 1980, this increased to 7.6%. By the same token, previously to 1980, the minimum degree of idle capacity was zero, whereas, after 1980, this was roughly 4.4%. Without further study, it is not clear if we should pick the average or the minimum as an estimate of a 'normal' rate. But both would suggest an increase of over 4 percentage points in 'normal' idle capacity after 1980. Why would this have happened? Lack of effective demand may hardly be argued to be the reason, because, in a number of years in this period (e.g.: 1986, 1989, 1995-96), inflation or external deficits clearly accelerated under the pressure of excess domestic demand. One hypothesis is that we may be understating the degree of idle capacity previously to the 1970s because our estimating procedure for this earlier period is very indirect, resulting from an inference about the rate of change of industrial production, and not from direct observation. Independently of agreement with our estimation method for 1940-68, it is still true that the observed levels of industrial capacity utilization in the early to mid-1970s were never again reached after 1980. Actually, it was only at the height of the demand boom provoked by the Real stabilization plan (1995 and 1997) and during the cyclical recovery of 2000 that the relatively low degree of industrial capacity utilization of 1968 was reached again in the post-1980 period.

To explain this sustained decline in capacity utilization rates is more than we can do here. Merely in terms of research topics, first in our list would be the successive defaults on domestic and external public debt in the 1980s. Subsequently to such debt defaults (which interrupted only temporarily the growth of public debt in Brazil) there seems to have occurred a substantial increase in the country's real rate of interest. An explanatory hypothesis is that the sequence of debt defaults raised both the required real interest rate and the required return on capital. This would have resulted in a higher desired mark-up over variable cost, thus tending to accelerate the rate of inflation for a given unemployment rate (or, equivalently in the short run, for a given capacity utilization rate). The implication is that the non-accelerating inflation rate of unemployment (or, equivalently in the short run, the 'normal' rate of idle capacity) would be higher than before.

The increase in Brazil's tax burden from the early 1990s would be second in line as a possible cause of the increase in idle capacity. A sharp rise in the share of 'informal labor' in total urban employment in the 90s accompanied this process. A plausible hypothesis is that the increased 'tax wedge' displaced economic activity from the more productive formal sector to the less productive informal sector, thus reducing the use of installed capacity in the formal sector.

Thirdly, at a more general level, the 1988 Constitution, coupled with subsequent legislation and judiciary decisions, seems to have increased the precariousness of the economic regulatory framework and, particularly, the uncertainty of contractual relations. A less trustworthy legal framework may also have raised the volatility of production and the 'normal' use of capacity.

In summary, our tentative hypothesis is that a series of post-1980 distorting policy interventions led to a higher degree of 'normal' idle capacity since then.

(9) Growth Accounting: a Synthesis

As illustrated in Figure 9, most of the time Brazil was outside the steady state, with v continuously chasing a moving v_{ss}. We have also seen that the rate of convergence of v towards v_{ss} is slow. This justifies centering our attention on the behavior of the capital stock and the GDP growth rates outside the steady state in a synthesis of Brazil's growth experience.

We start by defining six periods of approximately 10 years each, characterized by the origins and consequences of broadly similar economic policies. These periods are as follows:

1. War-end and post-war prosperity: 1942-52
2. Kubitschek era and its aftermath: 1952-64
3. Brazilian authoritarian 'miracle': 1964-74
4. External shocks and the waning of the military: 1974-84
5. Hyperinflation: 1984-93
6. *Real* era: 1993-2002

In Table 3 the capital stock growth rates for each of these epochs is decomposed, in accordance to equation (5), into its components **u** (capacity utilization), **v** (output to capital-in-use ratio), **p** (relative price of investment), and **s** (saving rate).

[Table 3 enters here]

The table confirms that capital stock growth proceeded at very fast rates up to the mid-1980s, peaking in the 'miracle' years (1964-74) at 8.5% yearly. But the behavior of its components changed markedly depending on the phase considered. Thus, average capacity utilization remained at high levels during the first three phases (1942 through 1974), at some 0.97. It declined sharply afterwards, especially in the 1974-84 period. The output to capital-in-use ratio, **v,** fell throughout the period, and its downward trend was also accentuated in the 1974-84 decade. The relative price of investment, in turn, rose continuously in all periods, and particularly strongly since 1984. From the last column in Table 3 we grasp that the saving rate, **s**, was the main source of capital stock dynamism until the early 1980s: it increased substantially from the early 1940s to 1974-84, reflecting a big build-up of foreign debt in this last period. Had it not been for this, the yearly capital stock growth rate in 1974-84 would have been much smaller, because of the contractionary forces of lower capacity utilization, diminished output to capital-in-use ratio, and higher investment prices. The collapse of capital stock growth after 1984 is explained mainly by the very adverse behavior of p, the relative price of investment. Also collaborating were declines in u and especially v, while s remained nearly unchanged. A small decrease in savings helps to explain the bad performance of K' in the last period in the table (1993-02), together with declines in v and 1/p. Capacity utilization, in turn, contributed to increase K'.

In summary, the main culprit of the slump in capital accumulation in the last 20 years seems to have been the rise in the relative price of investment that sharply reduced the purchasing power of savings. A simple exercise illustrates this conclusion. Suppose that p had remained through 2002 at its average level in the 'miracle' period, 1964-74, that is, 1/3 lower than the value observed in the 1984-2002 period. Then, ceteris paribus, the average capital stock growth rate would have been twice as high in 1984-2002. Recall that the phenomenon of a rising p was a Brazilian peculiarity, probably related to the economic insulation of the post-1974 period. Our tentative conclusion, thus, is that a more sensible response to the economic shocks of the 1970s would have avoided the plunge in capital accumulation observed over the last two decades.

Two alternatives to decompose GDP growth are discussed next. The first is according to the 'Y=AK model', as presented in Appendix 1, the final equation of which is reproduced below:

$$Y' = v' + u' + K', \tag{8}$$

where Y is GDP, v the output to capital-in-use ratio, u the degree of capacity utilization, and K the stock of capital in place—and where a (') after a variable denote its (logarithmic) rate of growth.

The results of this decomposition are shown in Table 4, according to the same previously identified periods. A finding in Table 4 is that the collapse of GDP growth in 1974-84 predated the fall in capital accumulation, which occurred only after 1984. In 1974-84, declining levels of capacity utilization (after 1980) and a rapidly decreasing output to capital-in-use ratio were responsible for a GDP growth rate half as large as the capital stock growth rate. The 1981-83 recession, induced by the debt crisis of the period, together with the highly capital-intensive industrialization drive of the previous seven years, share responsibility for this.

[Table 4 enters here]

Table 4 shows that, although the most proximate cause for GDP growth was capital stock growth, changes in capacity utilization and in the output to capital-in-use ratio were important determinants as well. Thus, one of the factors behind the 'Brazilian economic miracle' was an increasing degree of capacity utilization u, whereas changes in **v** contributed to lower the GDP growth rate in the 1964-74 period. The modest recovery of GDP growth in 1993-02 was also influenced by increasing capacity utilization, as the rate of capital accumulation continued to decline.

The second approach to decompose GDP growth is according to a traditional Solow-Swan production function, from which—as shown in Appendix 1—the following approximation is obtained, under the assumption that the elasticity of output with respect to both capital and effective labor is equal to 0.5:

$$Y' = (1/v)' + A' + L', \qquad (9)$$

where Y’ is the GDP growth rate, A’ is the rate of labor-augmenting technical progress, L’ is the growth rate of employment, and where (1/v)’ stands for capital deepening (i.e., the difference between the capital stock-in-use growth rate and that of effective labor.) Equation (9) shows that, outside the steady state, capital deepening shares with effective labor the explanation for GDP growth.

Before entering the numerical exercise, it is worth exploring the differences between equations (8) and (9). In one case (AK), v’ is positively contributing to GDP growth; while in the other (SS), it is its inverse, (1/v)’, that has a positive contribution to make. This role reversal is not difficult to explain. In (9), the critical variable for GDP growth is capital accumulation. To this we need to add the rate of change of capital productivity (i.e., v’) and that of capital utilization (u’) to obtain the output growth rate. In (9), the critical variable is the growth rate of effective labor (A.L). To this we need to add capital deepening [i.e., (1/v)’], or the additional contribution of capital accumulation, to obtain the growth rate of GDP.

Table 5 shows the results of the GDP growth decomposition expressed by equation (9). We added a last column to show the share of GDP growth explained by total factor productivity (TFP).

[Table 5 enters here]

The most important result of this table is to stress the crucial role of (1/v)’ to explain GDP growth in 1974-84: capital deepening (at 2.6% per year) was the main factor responsible to sustain an average GDP growth rate of 3.9% in this period, as the growth of effective labor (A’+L’) was only 1.4%. Moderate as it was, GDP growth in the last decade of the military regime could only be maintained on the basis of very high doses of capital deepening financed by external debt accumulation. External debt as a ratio to GDP increased to 43.1% in 1984 from 16.3% in 1974, while the ratio of debt service to merchandise exports zoomed up to 102.3% from 33.4%. (Cf. L. Gordon, 2001.)

In both 1964-74 and 1993-02 the contributions of capital deepening were very small or nil. But this does not mean that the economy was in a stable steady state. The reason why not is that v_{ss} did not remain constant in these periods, as shown in Figure 9. The importance of TFP change varied substantially through time, reaching negative values both during the external shocks period (1974-84)—when an amazing 1.7% per year rate of decline was observed—and in the hyperinflation years (1984-93). In the remaining periods, it represented a substantial share of GDP growth, with a high of 60% in the 'miracle' years. In the Cardoso years, had it not been for the recovery of A' (1.2% yearly, against –0.8% in the previous period), GDP growth would have been only 1.5%, instead of the observed 2.7% per year. Thus, from the perspective of decadal periods, the two 'lost decades' for TFP were not the 1980s and the 1990s but, rather, 1974-84 and 1984-93—the long and tormented transition from dictatorship to democracy, characterized by debt accumulation and hyperinflation.

This result depends critically on considering the 1974-84 period as a whole, which entails viewing the 1980-83 crisis as an integral part of the so-called 1974-80 forced march. An alternative would be to consider the shorter 1974-80 period in isolation and the longer 1980-93 period as a single block. Capital deepening as measured by (1/v)' characterized both periods, proceeding at 2.0% per year in 1974-80 and at 1.6% per year in 1980-93. But the collapse of GDP growth and technical progress occurred entirely within the latter period. Yearly GDP growth in 1974-80 was lower than in the "miracle" but still a respectable 6.9%. Technical change also declined sharply, but was still positive at 0.9% per cent per year. In contrast, average GDP growth in 1980-93 was only 1.6% and technical change was sharply negative at -2.3% per year. Thus, statistically speaking, the lost periods for Brazil's growth were not two entire decades, but the 13 years between 1980 and 1993.

In the *Real* period the contribution of raw labor, L', is very low—a fact related not to a decline of labor force growth but to reduced labor absorption. A possible explanation is that the rhythm of capital accumulation did not accompany that of technical progress, thus generating fewer employment opportunities at a given cost of labor.

(10) Conclusion: On Brazil's Growth Potential

Conclusions on Brazil's growth potential vary depending on the model used. In an AK perspective, presuming that the degree of capacity utilization, u, and the output to capital-in-use ratio, v, are constant, GDP growth can be approximated by the capital stock growth rate, K'. This can be written according to equation (5) as: $K' = s(1/p)uv-\delta$. Current values for the right-hand variables are approximately as follows: total saving rate (s) = 0.19; relative price of investment (p) = 1.0; average degree of capacity utilization (u) = 0.93; productivity of capital (v) = 0.34; and capital stock depreciation rate (δ) = 0.039. Plugging these values into the previous equation gives K' = 2.1%. This would be Brazil's current growth potential according to the AK model.

From the steady-state perspective of the Solow model, GDP growth is constrained by the sum of labor force growth, N' (currently 2.1% per year), with the rate of total factor productivity growth, A', which was on average 2.2% in the 2000-2002 period. This yields a potential GDP growth rate of 4.3%. From the fact that the growth rate of the capital stock, K', is lower than the growth rate of effective labor, A'+N', it follows, in a Solow-Swan context, that the short-run growth rate of output is lower that its steady-state value. With $\alpha = 0.5$ and assuming u constant and L'= N', this short-run GDP growth rate can be obtained as a simple average of the effective labor growth rate of 4.3% and the capital stock growth rate of 2.1%, that is, it is 3.2% per year. This would be the short-run (potential) GDP growth rate according to the Solow-Swan model.

Let us start from the lower end of these estimates, assuming v constant. In this case the short-run potential GDP growth is limited by capital formation (as in the AK model), that is, 2.1%. Consider the currently observed degree of capacity utilization, u = 0.93. Our results suggest an average level of capacity utilization of 0.95 for a recent period such as 1995-2000. This means that, as inflation converges to the long-term government target, there would be room for a moderate demand-pull growth spell. According to equation (8), increasing u from 0.93 to 0.95 raises the short term GDP growth rate by approximately 2 percentage points. But this is a once and for all gain if the growth rate of capital accumulation remains constant. If such higher level of u = 0.95 could be sustained on a permanent basis, according to equation (5) this would permit a very modest rise of the capital growth rate to 2.2% (against the previously calculated 2.1%).

More to the point would be policies dealing with the relative price of investment, p. This would be consistent with Jones (1994) empirical results on the negative relationship between economic growth and the relative price of investment and also with Rodrik's (1999, p. 27) admonition that: "because developing countries lack a comparative advantage in producing capital goods, trade restrictions in such industries tend to be detrimental to growth. Trade protection raises the relative price of capital goods and reduces the level of real investment that is attainable for any level of savings". Introducing market contestability seems to be a sensible course of action here: opening up to capital goods imports (for example, by doing away with the remnants of the infamous 1984 'informatics law'), together with sensible pro-competitive policies, could have an important impact. Thus, for example, if it were possible to make p return to values observed in the mid-1980s (p = 0.8), the capital stock growth rate would rise from the previously calculated 2.2% to 3.8%, ceteris paribus. Note that this implies that the saving rate at constant prices, s(1/p), would increase by 4.9 percentage points.

There remains the total nominal saving rate, s, which has been hovering around 19% for the past two decades—with the odd exception of higher values in the hyperinflation years. A higher domestic saving rate can be achieved in the medium to long term, as confidence-building measures increase private savings and the imbalances in the public sector accounts are dealt with in a lasting way. On the other hand, foreign savings are likely to remain negative in the medium term.

The exercises indicate that it is not difficult to imagine courses of action to make capital accumulation move up to 4.2%, at which point it would encounter the SS steady state technical progress constraint. To go further, ways and means of speeding up the rate of technical progress, A', would have to be considered. Our paper has little to offer in this direction. But current literature (e.g., Pinheiro, 2003) is aplenty with suggestions, involving higher human capital investment, tax reform, increased tradability, etc.

A final word of caution is in order. In this paper, we have followed truthfully the commands of the AK and Solow models, thus focusing attention on savings and technical progress as alternative but ultimate determinants of GDP growth. We ignored the limits posed by an autonomous investment function, as well as 'foreign exchange constraints' possibly reducing Brazil's growth potential. As to the former, it is our belief that the private sector's propensity to invest is unlikely to represent a major impediment to the country's growth rate, provided that remaining doubts about President Lula holding on to sensible economic policies are overcome. The foreign exchange constraint is a more delicate matter: some may argue that fiscal rectitude and a floating exchange rate are by themselves sufficient to overcome difficulties in this area. We are skeptical: until the country proves able to develop an on-shore long-term capital market, the need for offshore dollar denominated loans is unlikely to go away. Overcoming the jurisdictional uncertainties currently holding down the development of local long-term capital markets would seem to be the way to solve this problem. With this observation, we leave the important topic of jurisdictional uncertainty for treatment elsewhere (cf. P. Arida, E. Bacha, and A. L. Resende, 2004).

APPENDIX 1

THE 'Y=AK' AND SOLOW-SWAN MODELS

The 'Y=AK model', as presented in Bernanke and Gurkaynak (2001), starts from a neo-classical production function of the form:

$$Y = (uK)^{\alpha} (\tilde{A}hL)^{1-\alpha} \quad (1.1)$$

where:

Y = real GDP

u = degree of capacity utilization

K = real capital stock in place

Ã = exogenous technological factor

h = labor-augmenting skill factor

L = employment

α = elasticity of output with respect to capital-in-use

1-α = elasticity of output with respect to effective labor

Along the lines of Kenneth Arrow's classical 'learning by doing' 1962 article, Bernanke and Gurkaynak suppose that worker skills are proportional to the capital-in-use to labor ratio, namely, h = u.K/L. Then, the production function simplifies to:

$$Y = v.u.K, \quad (1.2)$$

where: $v = \tilde{A}^{1-\alpha}$

Equation (1.2) decomposes, in terms of growth rates, approximately as:

$$Y' = v' + u' + K' \qquad (1.3)$$

where a prime (') after a variable denote its (logarithmic) rate of growth.

The Solow-Swan model starts from a more traditional formulation of the neoclassical production function:

$$Y = (u.K)^{\alpha} (A.L)^{1-\alpha} \qquad (1.4)$$

where total factor productivity A is assumed to be labor-augmenting. Assume that α= 0.5. This convenient value is consistent with the income share of capital in Brazil's national accounts. It is also in accordance with the country's very high income concentration. Other recent studies of Brazil's growth experience have used values for α in the range of 0.35 to 0.50 (See Pinheiro et al., 2001; Bugarin et al., 2003; and Gomes et al., 2003). The adoption of values in this range would not materially change our conclusions. With α=0.5, from equation (4) GDP growth is:

$$Y' = 0.5(u' + K' + A' + L') \qquad (1.5)$$

Equation (1.5) asserts that, after correction for the degree of capacity utilization, in a Solow-Swan model capital accumulation, K', shares the explanation of GDP growth with effective labor (A' + L').

Note that (1.4) can be rewritten as:

$$Y = (1/v)^{\alpha/1-\alpha}(A.L) \quad (1.6)$$

where:

$$1/v = u.K/Y = (u.K/A.L)^{1-\alpha} \quad (1.7)$$

Equation (1.6) is being extensively used in recent literature dealing with international differences in income levels. For a review, see D. Romer (2001, pp. 138-140). This equation 'explains' GDP by effective labor, A.L, adjusted by a time-varying factor, 1/v, which is proportional to the capital-in-use to effective labor ratio, as shown in (1.7). From (1.6) we derive the following approximation to the decomposition of GDP growth, again assuming $\alpha = 0.5$:

$$Y' = (1/v)' + A' + L' \quad (1.8)$$

As can be inferred from (1.7), (1/v)' stands for capital deepening (i.e., the difference between the capital-stock-in-use growth rate and that of effective labor.) Equation (1.8) shows that capital deepening shares with effective labor the explanation for GDP growth. In steady-state, (1/v)' is constant and thus steady-state GDP growth depends only on the growth of effective labor.

APPENDIX 2

Estimating the Degree of Capacity Utilization (u)

Since 1968 there is an objective measure to grasp the level of u: it is the degree of industrial capacity utilization reported in the quarterly surveys conducted by the Vargas Foundation (FGV). A first problem is how to generalize the value of u in industry to the rest of the economy. We simply assumed that 65% of GDP was cyclically variable in tandem with industry, and the remaining 35% was always under full capacity: 65% would be our very rough estimate for the average share of non-farm business output in Brazil. This is the complement of the shares of (Agriculture + Government + Rents)/GDP, which, at factor cost, were as follows: 1950 = 44%; 1960=35%; 1970=32%; 1980=25%; 1985=28%. Thus, we defined the overall degree of capacity utilization as: $u = 0.65.(u_{ind}) + 0.35.(1.0)$, where u_{ind} is the degree of capacity utilization from the FGV surveys (annual averages). The second problem is identifying a level of utilization that could be called 'full'. In 1973 capacity utilization in industry reached 90% on a more or less sustained basis, and this is the maximum level in the whole series. Hence, we defined the overall level of capacity utilization in 1973 as full, that is we made u = 1.0 for 1973, and multiplied the levels of capacity utilization in the remaining years by 1.11.

Our procedure to grasp the value of u in the 1940-68 period was more tentative. It involved the estimation of a value for u_{ind} from an auto-regressive relation for the 1969-2003 period, in which this variable was made a function of the growth rate of manufacturing output and lagged u_{ind}. Simple inspection of the scatter diagram between the series suggested the existence of a structural break after 1985: for the same manufacturing growth rate the degree of utilized manufacturing capacity is slightly higher after 1985. Accordingly, a linear dummy was added to the model from 1985 on. The regression results were the following. (The correlogram of residuals indicates that the residuals of the regression are white noise):

Regression results — Dependent variable: u_{ind}

Adjusted R^2	0.9417			
Standard error	0.0113			
Number of observations	35	(1969-2003)		
Durbin-Watson	2.067			
	Coefficients	Standard error	Stat t	P-value
Intercept	0.153	0.04032	3.79	0.0007
Manufacturing output growth rate	0.0039	0.00032	12.18	0.0000
$u_{ind}(-1)$	0.7815	0.04807	16.26	0.0000
Dummy 1985-2003	0.0176	0.00463	3.79	0.0006

Next we chose 1936 as the base-year from which to start simulating values of u_{ind} from 1940 to 1968, using the above regression. Trial and error led us to arbitrate the value of u_{ind} = 0.87 in 1936. This is a very high value in the series, corresponding to the level achieved in 1976. The justification for such a high estimate are the very high growth rates of manufacturing output in 1936 and in the immediately preceding years: 11.7% (1933), 11.1% (1934), 11.9% (1935) and 17.2% (1936). These rates are similar to those observed during the Brazilian 'miracle' in the early 1970s. See IBGE (1990). The adoption of this procedure yields an estimate of 0.844 for the value of u in 1969, very close to the observed value of 0.847. With such simulated values of u_{ind}, we obtained values for the economy-wide degree of capacity utilization using the same procedure adopted for the 1968-2002 period.

REFERENCES

Arida, P., Bacha, E., and Resende, A. L., 2004. Credit, interest, and jurisdictional uncertainty: conjectures on the case of Brazil, in: F. Giavazzi and I. Goldfajn (Eds.), Inflation Targeting and Debt: the Case of Brazil. MIT Press, Cambridge, MA.

Arrow, K., 1962. The economic implications of learning by doing. Review of Economic Studies 29, 155--173.

Bernanke, B. and Gurkaynak, R., 2001. Is growth exogenous? Taking Mankiw, Romer, and Weil seriously. NBER Working Paper 8365, July.

Bonelli, R. and Fonseca, R., 1998. Ganhos de produtividade e de eficiência: novos resultados para a economia brasileira. Pesquisa e Planejamento Econômico 28.

Bugarin, M.S., Ellery Jr., R., Gomes, V., and Teixeira, A., 2003. The Brazilian depression in the 1980s and 1990s. University of Brasilia, Brasilia.

Carneiro, D. and Werneck, R., 1993. Obstacles to investment resumption in Brazil, in E. Bacha (Ed.), Savings and Investment Requirements for Growth Resumption in Latin America. Washington, DC: Inter-American Development Bank/Johns Hopkins U. Press, Washington, DC, pp. 67-108.

Gomes, V., Pessoa, S., and Veloso, F, 2003. Evolução da produtividade total dos fatores na economia brasileira: uma análise comparativa. Pesquisa e Planejamento Econômico 33

Gordon, L., 2001. Brazil's Second Chance. Brookings Institution Press, Washington, DC.

Heston, A., Summers, R., and Aten, B., 2002. Penn-World Table Version 6.1". Center for

International Comparisons at the University of Pennsylvania.

IBGE, 1990. Estatísticas Históricas do Brasil — 1950-1989. Fundacao Instituto Brasileiro de Geografia e Estatistica, Rio de Janeiro.

Jones, C. I., 1994. Economic growth and the relative price of capital. Journal of Monetary Economics 34, 359-382.

Morandi, L. and Reis, E., forthcoming. Estimativa do estoque de capital fixo – Brasil, 1950-2000. Texto para Discussão, IPEA, Rio de Janeiro.

Pinheiro, A. C., Gill, I.S., Serven, L., Thomas, M.R., 2001. Brazilian economic growth, 1900-2000: lessons and policy implications World Bank, Washington, DC.

Pinheiro, A.C 2003. Uma agenda pós-liberal de desenvolvimento para o Brasil. Seminar Series, IPEA, Rio de Janeiro.

Rodrik, D., 1999. The New Global Economy and Developing Countries: Making Openness Work. Overseas Development Council, Washington, DC.

Romer, D., 2001. Advanced Macroeconomics. McGraw Hill, 2nd ed.

Table 1: Correlation matrices

A: 1941-2002	Y'	K'	u	V	p	s
Y'	1.000					
K'	0.515	1.000				
u	0.700	0.718	1.000			
v	0.368	0.504	0.514	1.000		
p	-0.533	-0.854	-0.650	-0.679	1.000	
s	-0.166	-0.020	-0.199	-0.778	0.425	1.000
B: 1952-2002	**Y'**	**K'**	**u**	**V**	**p**	**s**
Y'	1.000					
K'	0.604	1.000				
u	0.739	0.714	1.000			
v	0.593	0.837	0.684	1.000		
p	-0.590	-0.861	-0.605	-0.922	1.000	
S	-0.199	-0.084	-0.188	-0.541	0.509	1.000

Table 2: Regression results — Dependent variable: v

Adjusted R^2	0.9814			
Standard error	0.0040			
Number of observations	62	(1941-2002)		
Durbin-Watson	1.484			
	Coefficients	Standard Error	Stat t	P-value
v (-1)	0.9590	0.0020	484.387	0.0000
V (ss)	0.0359	0.0019	18.526	0.0000

Table 3: Decomposition of Capital Stock Growth Rates, 1942-2002

Periods	K'	U	v	p	s
1942-52	0.077	0.969	0.591	0.615	0.122
1952-64	0.078	0.975	0.493	0.632	0.154
1964-74	0.085	0.963	0.469	0.649	0.186
1974-84	0.078	0.940	0.408	0.751	0.222
1984-93	0.031	0.915	0.355	0.978	0.210
1993-02	0.024	0.943	0.340	0.993	0.196

Table 4: Decomposition of Output Growth Rates - AK model, 1942-2002

Periods	Y'	K'	u'	v'
1942-52	0.069	0.077	0.005	-0.011
1952-64	0.067	0.078	-0.001	-0.008
1964-74	0.088	0.085	0.004	-0.002
1974-84	0.039	0.078	-0.011	-0.025
1984-93	0.025	0.031	0.002	-0.008
1993-02	0.027	0.024	0.002	0.001

Table 5: Alternative Decomposition of Output Growth Rates - Solow model, 1942-2002

Periods	Y'	(1/v)'	L'	A'	A' / Y' (%)
1942-52	0.069	0.011	0.021	0.035	51.1
1952-64	0.067	0.008	0.025	0.032	48.1
1964-74	0.088	0.002	0.032	0.052	59.0
1974-84	0.039	0.026	0.031	0.017	-43.5
1984-93	0.025	0.008	0.025	-0.008	-32.0
1993-02	0.027	-0.001	0.016	0.012	43.1

FIGURE 1: GDP growth rates, 1940-2002

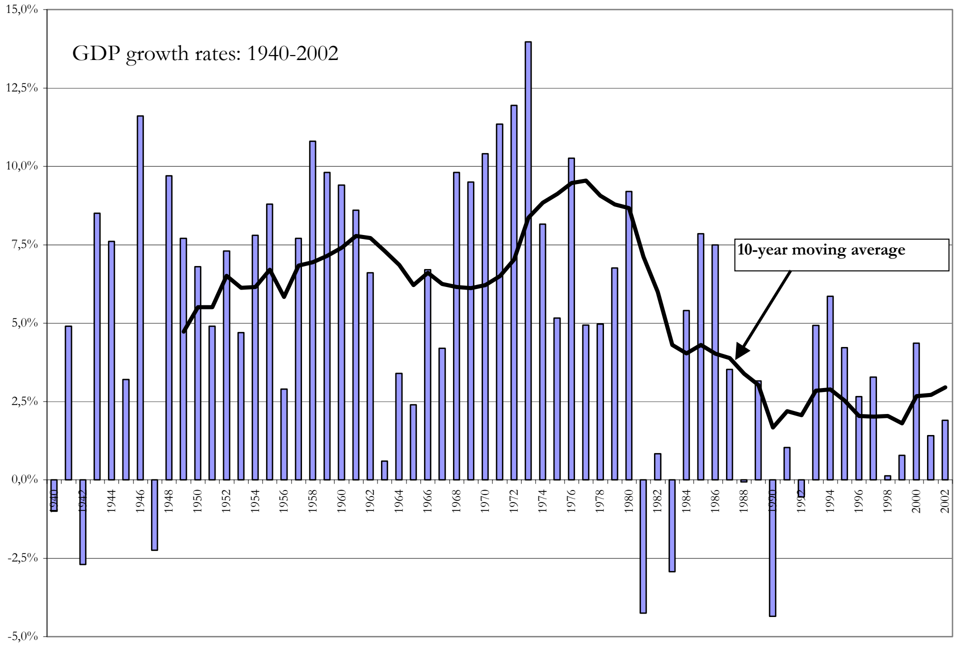

FIGURE 2: GDP and Capital Stock growth rates, 1941-2002

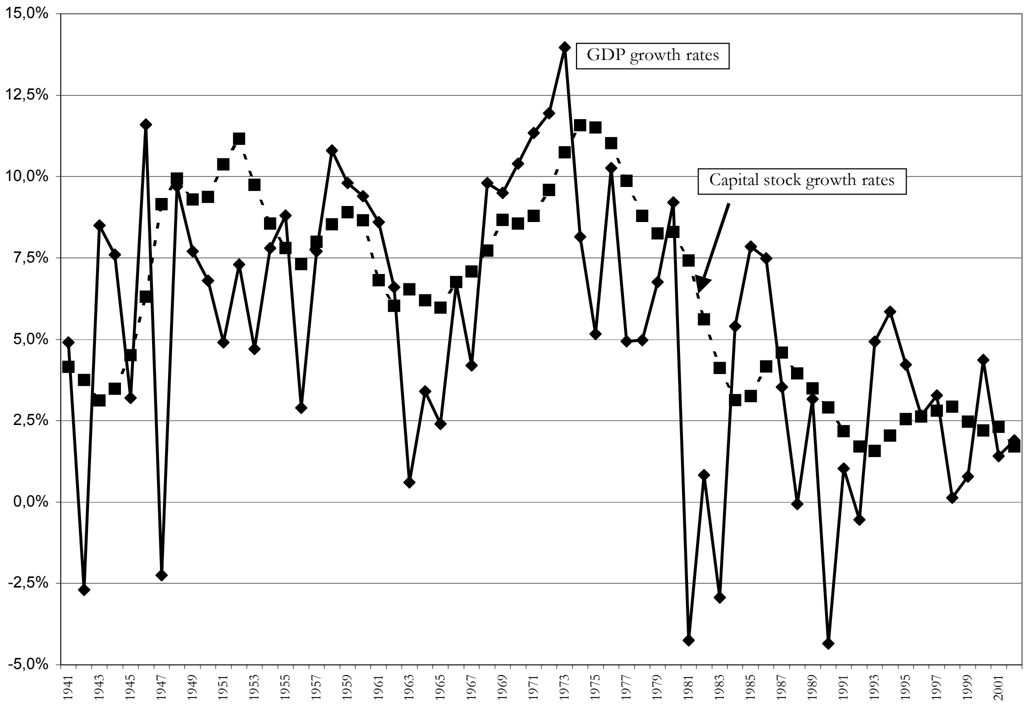

FIGURE 3: Saving rates, 1940-2002

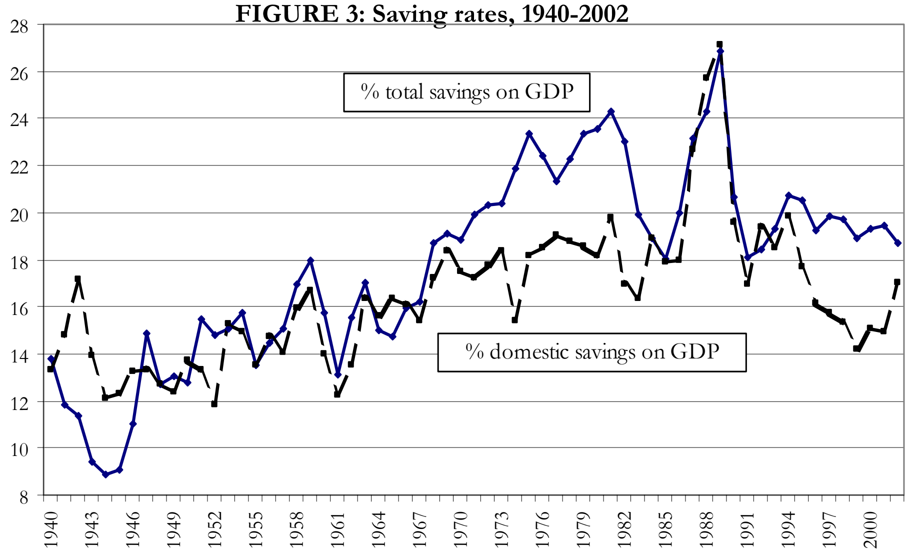

FIGURE 4: Relative price of investment, Brazil and world, 1950-2000

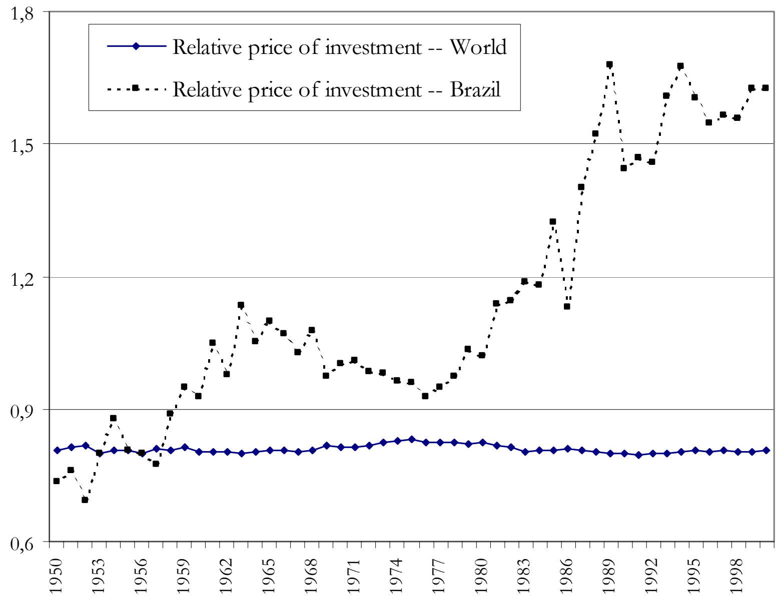

FIGURE 5: Output to capital-in-use ratio (v), 1940-2002

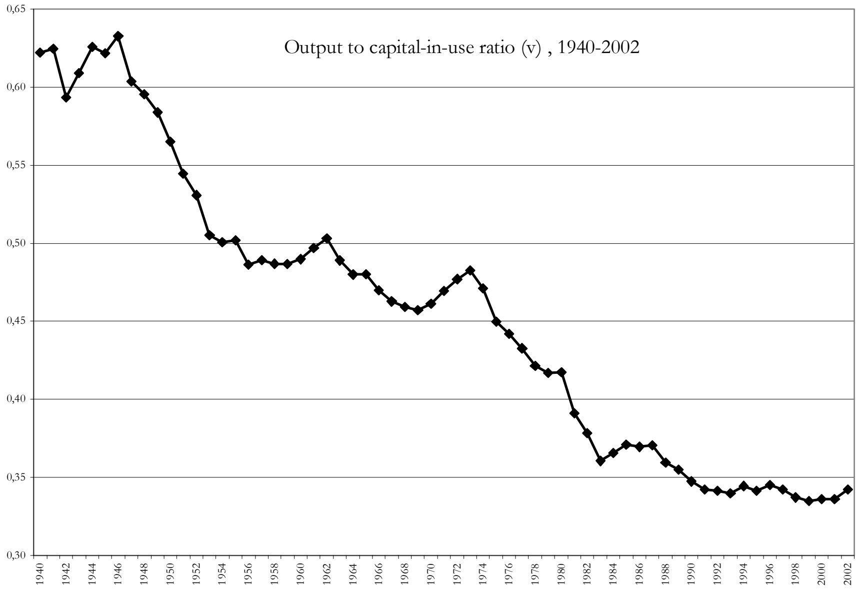

FIGURE 6: Negative correlation between v and p since 1952

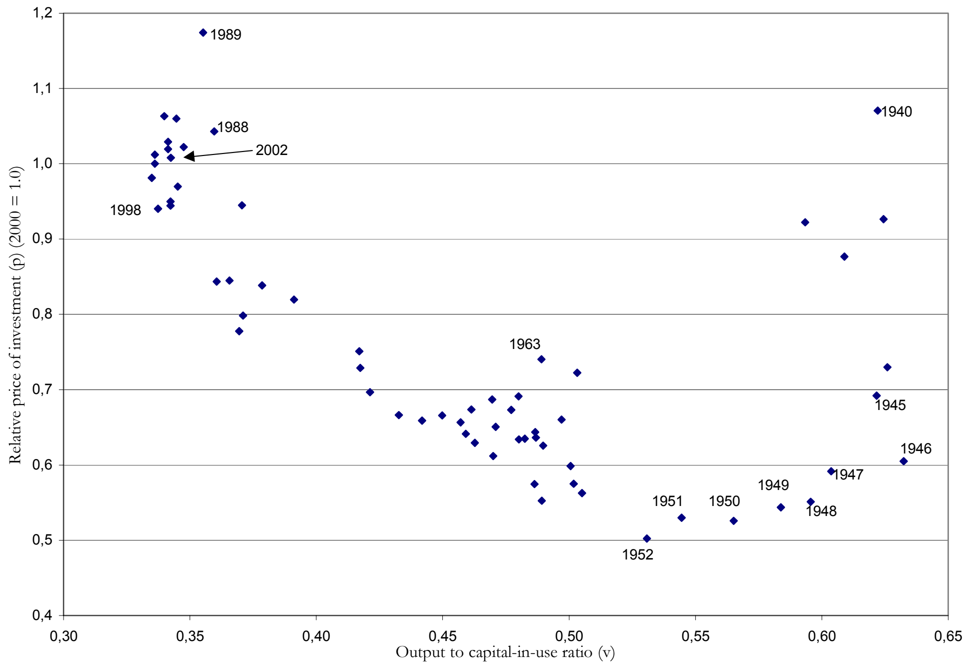

FIGURE 7: Output-capital ratios, Brazil and world, 1950-2000

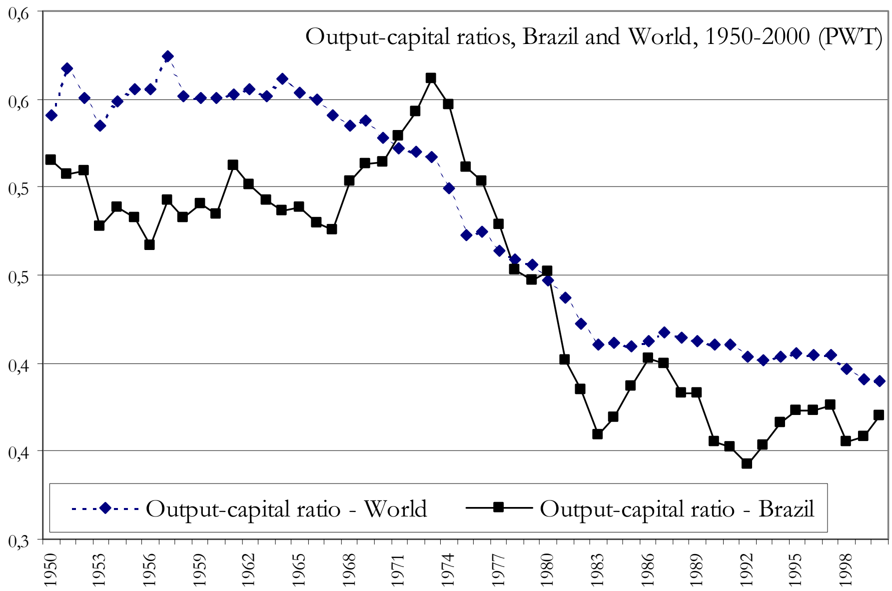

FIGURE 8: Working force growth (N') and steady states values of $Y'_{ss} = K'_{ss} = A' + N'$ (A' = TFP), 1941-2002

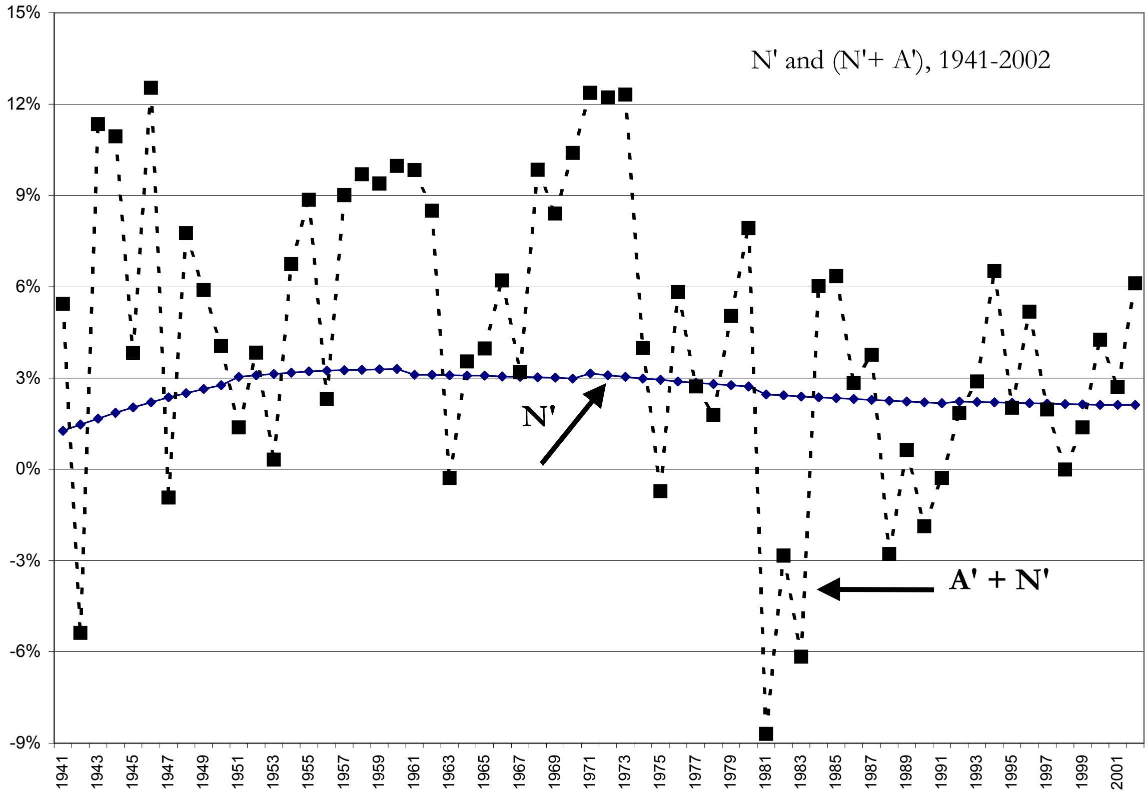

FIGURE 9: Steady state and observed values of the output to capital-in-use ratio (v), 1941-2002

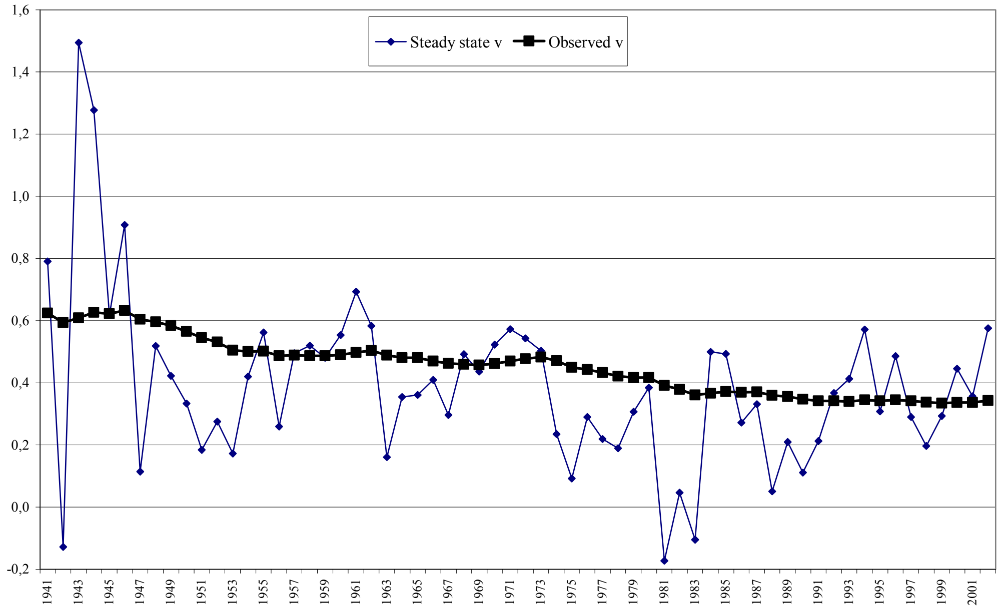

FIGURE 10: Idle capacity (%) 1940-2002