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**Estimating Brazilian Potential Output:
A Production Function Approach¹**

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Abstract

Estimating potential output involves a high degree of uncertainty. At the same time it has great importance to policymakers, an unpleasant combination. This uncertainty fostered the emergence of several methods aiming at estimate potential output. In this paper, the production function approach was chosen because it has important advantages compared to others, although it also has limitations. Preliminary results for the Brazilian economy are as follows: a) total factor productivity (TFP) decreased in the last two decades, however, this negative trend was reversed after 1992 and, since then, TFP has been growing, on average, 0.9% per year; b) since 1980, most of the time the Brazilian economy has been operating below its potential. The years with strongest economic activity were 1980, 1985 and 1986; c) simulations involving different scenarios for investment and TFP growth rates, show that the average potential output growth for the 2001-05 period should be between 3.3% and 4.5%; d) although these figures are lower than those registered before 1980, they are higher than the average GDP growth in the last two decades; e) due to the deep structural changes that the Brazilian economy has been experiencing recently, TFP growth can be expected to increase in the next years. Even so, without increasing investment rates significantly, Brazil will not grow at rates close to its historical average.

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“Until the laws of thermodynamics are repealed, I shall continue to relate outputs to inputs – i.e. to believe in production functions. Until factors cease to have their rewards determined by bidding in quasi-competitive markets, I shall adhere to (generalized) neoclassical approximations in which relative factor supplies are important in explaining their market remunerations.”

Paul A. Samuelson

1 - Introduction

After several decades of strong economic growth, that made Brazil one of the fastest growing countries in the twentieth century, the 80's were characterized by the conjunction of two factors: a strong fall in the growth rate of the Brazilian economy and a great increase in the inflation rate, a situation that prevailed until the middle of the nineties, and that led to the implementation of seven stabilization plans in less than ten years.³

This situation had a great influence on the national economic literature, since long run matters slowly lost terrain among economists' interests. Important themes, such as potential output estimation, were not a regular research subject since then, as shown by the small number of papers written about it. However, this phenomenon is not difficult to be understood, since a country's academic literature contemplates, largely, its own reality.

It is true that the negative effects provoked by the oil shocks in the seventies motivated, in a first moment, the emergence of papers analyzing why the growth rate of Brazilian economy had fallen and attempts to determine its potential output as well. However the inflationary disarray and the resulting macroeconomic instability attracted economists' attentions in the eighties and nineties. In fact, since the end of the 70's and the beginning of the 80's, with the worsening of the inflationary process, attentions turned from the binomial economic growth/development to the binomial reduction/control of inflation and, consequently, economic development plans were replaced by stabilization plans.

³ Between 1986 and 1994, seven stabilization plans were implemented in Brazil.

Although the Real Plan, implemented in mid-1994, was successful in reducing the inflation rate to 1.65%, in 1998, from 965%, in 1994, during that entire period there was a persistent concern regarding its vulnerabilities and, therefore, sustainability, leaving the economic growth issue to a second stage.⁴ Indeed, the concerns with inflation resumed strongly in January 1999, after the collapse of the fixed exchange-rate regime, when inflation forecasts peaked at 80%. Searching for a new nominal anchor for the Brazilian economy, the government decided to implement the inflation-targeting regime in July 1999. And, in spite of the huge exchange-rate shock and the doubling of oil prices, initial forecasts proved to be wrong, with annual inflation in 1999 remaining below 9%.

It can be said that 1999 was a unique year in Brazilian economic history, not only because of the extremely successful transition to the flexible exchange-rate regime but, above all, with the recognition of Brazilian society, proved by the adoption of the inflation targeting regime, that price stability is the main goal of any responsible central bank.

After the floating of the currency, once questionings about price stability vanished, without the restrictions imposed by an overvalued currency and with a tight fiscal policy, the theme of sustainable economic growth gained prominence quickly. In consequence, in 2000, medium and long-term issues came again, after a long time, to the main agenda of economic debates and Brazilian politicians. In this context, potential output estimation is a fundamental issue.

The importance of potential output also stems from the fact that the output gap is a key-variable in forecasting inflation and in studying the transmission mechanism of monetary policy. Furthermore, the output gap is essential to evaluate what is the neutral real interest rate, and helps to assess the real stance of fiscal policy, since it is needed to calculate the so called full employment, or structural, deficit.

The goal of this paper is to estimate the Brazilian potential output and, therefore, output gap since 1980. Additionally, potential output projections, under alternative scenarios, are made for the period 2001-05. During that process, estimates of total factor

⁴ According to the broad consumer price index (IPCA).

productivity (TFP) for Brazil, a fundamental variable to evaluate how fast the Brazilian economy can grow in the future, are also obtained. Last, the sources of growth for the Brazilian economy in the last twenty years will be shown, assessing the role played by labor and capital input and TFP as well.

The paper is organized as follows. Section 2 presents a brief critical survey of the main papers regarding Brazilian potential output. Section 3 shows TFP estimates for Brazil in the last two decades. Then, for the same period, the main sources of growth for the Brazilian economy are shown. Following, the production function method is explained and potential output and the output gap for Brazil are estimated for the 1980-2000 period. Finally, some exercises are done in order to show the uncertainty surrounding potential output estimations. In section 4, several scenarios for the Brazilian economy are considered for the 2001-03 period, along with projections of the average potential output growth rate. The main conclusions of the paper are presented in Section 5.

2 - Brazilian Potential Output: a Brief Review

Among the main essays written in Brazil on potential output are those of Suzigan et alli (1974) and Bonelli and Malan (1976), who estimated potential output for the manufacturing industry only, for the periods 1954-1972 and 1954-75, respectively. Both adopted the capital to output ratio method to calculate potential output, which shortly consists of: a) estimating the capital stock during the desired period; b) calculating for each year the capital to output ratio; c) considering the year with the smallest ratio as the one in which output is equal to its potential; d) dividing the capital stock for each year by that ratio in order to determine the potential output for the whole period.⁵

Later on, Bonelli and Malan (1983) determined the Brazilian potential output from 1970 to 1982, by estimating a regression with GDP growth as the dependent variable and one-period lagged investment rate as the independent variable, besides the constant.⁶ Then, a specific year was assumed as having zero output gap and, using the estimated

⁵ Bonelli and Malan (1976) have also estimated potential output fitting an exponential function through the peaks of the series.

⁶ The authors have also made projections for the 1983-1986 period.

regression, the potential output series for the entire period was built. Doellinger and Bonelli (1987) used a similar method to estimate potential output for the 1970-1986 period. However, in their study potential output was the dependent variable and one-period lagged potential output and current investment rate were the independent variables. They didn't include the constant.

In a paper whose main objective was to estimate an historical series for the incremental capital to output ratio, Matesco and Pinheiro (1989a,b) needed to obtain a variable that would measure the capacity utilization for the whole economy, in order to smooth the original series. For that, isolating the GDP trend and adjusting it so as to coincide with those years considered by the authors as having zero output gap, potential output was estimated.

Carvalho (1996) estimated a reduced form of aggregate supply and demand curves in order to determine potential output. Then, by identifying temporary demand and supply shocks, the regression's independent variables were smoothed with the aim of finding their "potential levels" and, therefore, determine potential output. Some variables were smoothed by means of a linear combination between their trends and the variable itself, while for others their moving average was used.

Recently, in a paper whose main objective was to uncover productivity measures of the Brazilian economy, Bonelli and Fonseca (1998) used estimates of potential output changes for 1973-97, with the aim of obtaining estimates of total factor productivity. They used the capital to output ratio method to calculate potential output *changes*, with the difference that the capital stock was determined using techniques from the theory of investment. However, as mentioned, only estimates for the rate of variation of the potential output were obtained.

It is worthwhile to make some comments on the aforementioned methods. The capital to output ratio method has some important limitations. First, it assumes that the economy can be represented by a Leontieff production function, which has the capital input as a limiting factor. That means that the elasticity of substitution between capital and labor is zero, an unlikely hypothesis. Second, the method does not take into account technical progress. Third, it is assumed that the capital to output ratio remains constant for the

entire period, which is a very strong hypothesis that affects the level and the rate of change of the potential output. Fourth, it is necessary to admit that in a given year the output gap is zero. The output gaps in the other years of the series are extremely sensitive to that assumption. Moreover, it is worth noticing that, if in the future a given year has a smaller capital to output ratio, then that year in the past previously considered as having a zero output gap, will afterward show a negative gap. That doesn't make sense. Fifth, the largest output gap possible is always equal to zero, a limitation that also exists in Matesco and Pinheiro (1989a,b), who have adjusted a trend line to the peaks of the original series. Moreover, during its determination, they supposed that potential output grows at a constant rate in the analyzed period.

Although the method used by Carvalho (1996) differs from the others for being a more rigorous technique, it also presents some limitations. For example, the method he uses to identify demand and supply shocks doesn't seem to be the most appropriate, and has important consequences in the determination of the variables "potential levels".⁷ Another problem is the existence of coefficients that are not statistically significant in the estimated equations. As a result of these and other limitations, which won't be discussed here, the estimated depreciation rate reaches, in some scenarios, negative values. Last, the capital to output ratio is very sensitive to the period considered.

3 - Potential Output and the Production Function

The estimation of potential output involves a high degree of uncertainty. This is largely due to the fact that it is not a directly observable variable. Besides, potential output also depends on variables that are non-observable such as, for example, the natural rate of unemployment and the rate of depreciation of the capital stock. In consequence, several methodologies were created for this purpose, and there is not a consensus on which is the best method. This is not a comfortable situation, especially for policymakers, since a misperception regarding the magnitude of the output gap can worsen the existent, but unknown, unbalances of the economy. Note that, uncertainty is more harmful the closer to full employment is the economy.

In this paper, the traditional production function method was chosen to determine the potential output, because it has important advantages, such as:⁸ a) it relates inputs to outputs, a quite intuitive and accepted fact by economists. If investment increases, the economy's productive capacity will also increase. The same thing will happen if there is an increase in the amount of labor; b) TFP estimates are obtained during the estimation of potential output. TFP is the main indicator of economic aggregate efficiency and one of the central determinants of economic growth; c) the production function method is quite flexible, because it can deal with different technologies and with some advances of the new growth theory, such as changes in the quality of inputs (e.g. human capital). Moreover, it is possible to take into account and determine the effects of economic policy changes on potential output, such as modifications in the social welfare system, unemployment benefits and workweek length; d) in spite of the high uncertainty associated to its determination, potential output forecasts are simple and intuitive. The path of labor input is strongly correlated with population growth, which is an easily to forecast variable.⁹ Besides, the production function method allows enough flexibility so that policymakers can exercise their judgment about how the key variables will evolve and affect growth. On the other hand, capital stock estimates carry considerable uncertainty.¹⁰

As equation (1) shows, it is assumed that the structure of Brazilian economy can be represented by the Cobb-Douglas technology, along with its traditional features: each input has decreasing marginal returns, the function has constant returns to scale, the elasticity of substitution equals to unity, and productivity is neutral in the sense of Hicks.

$$Y_t = A_t K_{t-1}^\alpha L_t^{1-\alpha} \quad (1)$$

Where: Y is GDP, K represents capital services and L labor services, while A is the

⁷ This methodology is based on the work of Blanchard and Quah, and assumes that over the period under analysis the economy converges to its potential.

⁸ See Cerra and Saxena (2000) for other methodologies.

⁹ Actually, the task is not so simple because other variables should also be considered to forecast the labor force such as, for example, changes in life expectancy and in the population profile. Anyway, as these changes occur slowly, the uncertainty is much smaller when compared to other inputs or variables forecasts.

¹⁰ Once capital stock is determined the projections are relatively easy since they depend, essentially, on the depreciation rate and the investment rate. Generally, the depreciation rate is assumed constant, while the investment rate is relatively stable during short periods of time.

contribution of technology, in spite of the fact that it is called TFP. The exponents can be interpreted, under certain conditions, as capital and labor participation in income.

Although the traditional functional form of the Cobb-Douglas technology relates the current capital stock to current production, in practice a small adjustment should be made. As can be seen, equation 1 supposes that output in "t" is determined by the capital stock in "t-1". This lag is intuitive, since it takes some time for investment to increase the economy's production capacity.

The estimation of the potential output is made in two stages. In the first, TFP is obtained using growth accounting technique. Note that, as potential output, TFP is an unobserved variable. In order to obtain accurate TFP estimations, it is extremely important that the flow of services of capital and labor be accurately measured. Once TFP figures are obtained, the potential or "full employment" level of each input is determined and, together with the TFP trend, potential output is determined by means of the Cobb Douglas production function.

A) Defining and Measuring the Inputs

It is a difficult task to measure the capital input, whether in theoretical terms or in practical grounds. Furthermore, there are no available estimates of the economy's capital stock. The usual solution is to build the series using a simple procedure, but is not free of problems. On the contrary, because there are considerable uncertainties associated to the process. With this aim, the perpetual inventory method was used:

$$C_t = (1 - \delta)C_{t-1} + I_t \quad (2)$$

where: C is the capital stock and I is the level of gross capital formation and the δ parameter represents the capital stock depreciation rate.¹¹

Equation (2) can also be represented as:

¹¹ From here on, gross capital formation and investment will be employed as synonyms. Note, however, that investment encompasses not only gross capital formation, but also inventories.

$$C_t = (1 - \delta)^t C_0 + \sum_{i=1}^t (1 - \delta)^{t-i} I_i \quad (3)$$

where: C_0 is the initial capital stock.

Equation (3) is useful as it shows that to calculate the capital stock it is necessary to know, in addition to the amount of investment, the initial value of the capital stock and the depreciation rate. It is exactly in the last two variables that the problem resides, because their values are not known with reasonable precision, unlike the investment rate.

There are hardly any estimates of the depreciation rate for the Brazilian economy. Estimates from Carvalho (1996) vary between 3.56% and 4.32%, whereas Bonelli and Fonseca (1998), using investment theory techniques, obtained 3.1% as the depreciation rates value.¹² These numbers seem underestimated, whether compared to international figures, or simply on theoretical grounds.¹³ Hence, 5% was chosen as the depreciation rate for Brazil, since it is a commonly used rule of thumb value for the variable (Jones, 2000). Notice that in spite of the fact that a constant rate of depreciation is commonly adopted in the literature, it is likely that the depreciate rate varies along the economic cycle, accelerating during expansions and contracting during recessions.¹⁴

Regarding the initial capital stock, it is possible to get an estimate of its value using equation (3) and assuming that $I_j = (1 + g)I_{j-1}$. In that case, we have:

$$C_0 = (1 - \delta)^n C_{-n} + \sum_{i=0}^{n-1} \left(\frac{1 - \delta}{1 + g} \right)^i I_0 \quad (4)$$

Taking the limit when "n" goes to infinity, the initial capital stock can be determined:

¹² Estimates from Carvalho are particularly sensitive to the assumptions used.

¹³ For example, according to Nadiri and Prucha, "Estimation of the Depreciation Rate of Physical and R&D Capital in the US Total Manufacturing Setor", 1993, NBER Working Paper N° 4591, the capital depreciation rate in the United States manufacturing industry is 5.9%.

¹⁴ There is no consensus regarding this issue, because during recessions firms may renew their machines and equipments.

$$C_0 = \frac{(1+g)}{(g+\delta)} I_0 \quad (5)$$

According to equation (5), the capital stock in 1970 corresponded, approximately, to a capital to output ratio equal to 3.3.¹⁵ Note that this is just an estimate because, among other things, it is assumed that investment grows at a constant rate equal to “g”.¹⁶ However, unlike the depreciation rate, it is possible to minimize considerably the effects of the uncertainties regarding the initial capital stock estimation. For that, a capital stock series that goes sufficiently backward is needed so that, in the beginning of the period under analysis, the initial capital stock has been depreciated to a large extent, and the hypothesis regarding its initial value has little relevance. With that aim, the capital stock was calculated starting from 1970 so that, in 1980, the beginning of the period under analysis, the initial capital stock had already depreciated for ten years. Obviously, a longer series would be better, but due to data limitations this was not possible.¹⁷

Once the capital stock is obtained, it is necessary to compensate for changes in its intensity of use, otherwise its services will not be correctly measured. To do so, the capital stock was corrected by the capacity utilization (CU).¹⁸ Note that this correction is just an approximation, since the capacity utilization indicator doesn't measure the degree of use of the whole capital stock, but only that of the manufacturing industry. Thus, we have:

$$K_t = C * CU \quad (6)$$

Graph (1) exhibits important results concerning the development of the capital to output ratio for the Brazilian economy. First, in the last twenty years this ratio has been

¹⁵ In 1999 constant values.

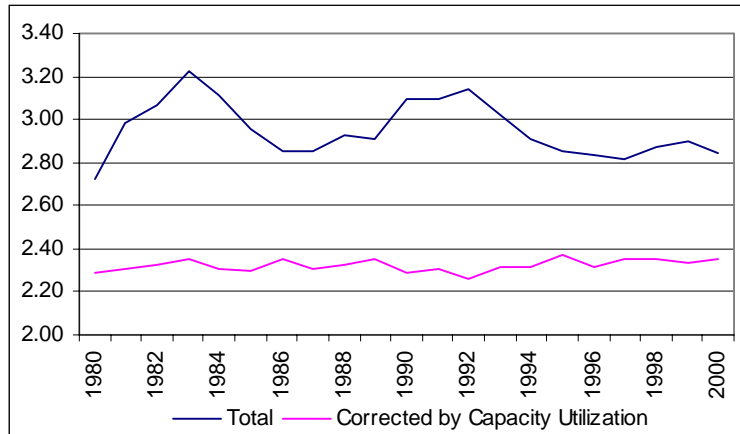
¹⁶ There are several other factors that contribute to the uncertainties regarding the estimation of capital stock as, for example, problems involving the aggregation of different kinds of capital. However, these problems will not be considered in this paper.

¹⁷ Using a depreciation rate of 5%, in ten years the initial capital stock would have depreciated 37%. Notice that this number is much more significant than it may seem, since what matters is the difference between "the true", but unknown, capital stock and its estimate. Simulations for the Brazilian economy starting in 1970, using real investment rates and supposing that the initial capital stock is overestimated in 50%, show that after 10 years the difference between the estimate and the “true” capital stock decreases to just 17%. If the initial capital stock is overestimated in 30%, the difference falls to 10%.

¹⁸ There are three capacity utilization indicators published in Brazil. In this paper, the average of the quarterly index published by the Getúlio Vargas Foundation is used. It is preferred because it encompasses a larger sample.

oscillating around 3. In the beginnings of the eighties and nineties it rose as a consequence of the 1981-83 and 1990-1992 recessions. In the 90's, it experienced a decrease due to the fall in investment rates in that period.¹⁹ Second, when capacity utilization is taken into consideration the capital to output ratio shows remarkable stability.

Graph 1
Capital to Output Ratio



In opposition to capital input, the uncertainties regarding labor input are much lower. In this paper the labor input (L) is represented by the labor force (LF); however, so that the labor force reflects labor services appropriately, some important corrections should be made.²⁰ First, as done with capital input, it is necessary to consider changes in the intensity of use of labor input. Second, it is necessary to understand the limitations of the labor force concept as an indicator that gauges the available number of people ready to work, and to make eventual corrections, so that it reflects more appropriately what we want to measure.²¹

Changes in the intensity of labor use were taken into consideration by correcting the labor force by the unemployment rate (u). As long as unemployed people are not contributing to production, they should not be considered. Moreover, as will be seen

¹⁹ In 1999 constant prices the average investment rate fell to about 19%, in the decade of 90, from 23%, in the decade of 80.

²⁰ A more accurate measure of labor services would be number of hours worked; however, due to data limitations, the number of workers in the labor force is used.

²¹ Note that the labor force calculation methodology changed after 1991 with the broadening of the labor concept. Therefore, the published series after that was corrected to become compatible with the old concept.

below, without these corrections TFP estimates will be distorted. Another important point is that, due to the definition of the labor force those who, by chance, don't look for a job during the research reference period won't be counted as part of the labor force, although they are available and eager to work. That means that labor force underestimates, in greater or lesser extent, the number of people able to work at a given time.²²

This phenomenon, here denominated “discouragement effect”, can be easily observed during recovery periods when, in a first moment, the unemployment rate increases instead of decreasing, since the number of people that join the labor force is larger than the number that get a job. In addition, this peculiarity can provoke a fall in the labor force, an unusual phenomenon that should be taken into account, because it contradicts the fact that, usually, population grows over time.

Seeking to attenuate the “discouragement effect” the original series was “smoothed” by imposing some restrictions on the number of people that compose the labor force and on the participation rate (r) as well, defined as the working age population (WP) to labor force ratio.

$$r_t = \frac{LF_t}{WP_t} \quad (7)$$

$$LF_t^* = \bar{r}_t WP_t \text{ where } \begin{cases} \bar{r}_t = r_t, & \text{if } r_t \geq r_{t-1} \\ \bar{r}_t = r_{t-1}, & \text{if } r_t < r_{t-1} \end{cases} \quad (8)$$

$$\begin{cases} \overline{LF}_t = LF_t^*, & \text{if } LF_t^* \geq LF_{t-1}^* \\ \overline{LF}_t = LF_{t-1}^*, & \text{if } LF_t^* < LF_{t-1}^* \end{cases}$$

$$L_t = \overline{LF}_t (1 - u_t) \quad (9)$$

Therefore, the restrictions above prevent the labor force in a given year from being lower than in the previous year. That is an unusual phenomenon but, indeed, it happened in 1996. In this case, the 1996 labor force was considered as being equal to the 1995 labor force. Besides, since the participation rate keeps growing, when “ r ” drops the fall is attenuated, as long as, in this case, the working population is multiplied

²² This underestimation is larger during recessions because the incentive to look for work is weaker.

by previous year's participation rate.²³

It is important to note that the traditional smoothing method (time trend, HP filter, etc) is not a proper technique in this case, because that method is justified only when the variable under analysis has its behavior strongly influenced by economic activity as, for example, tax revenues. That is not the case of the number of people available to work.

It should also be observed that, even for long periods of time, the labor force might not grow at the same rate of population. Basically, that difference is possible as a consequence of changes in life expectation and socioeconomic conditions. These changes appear in the participation rate that varies over time.

The variable "A" can be obtained directly from equation (1). Taking the log of the production function and deriving it with respect to time one obtains:

$$\dot{a} = \dot{y} - \alpha \dot{l} - (1 - \alpha) \dot{k} \quad (10)$$

That is, TFP's growth rate is determined by the difference between output's growth rate and a weighted average of production factors' growth rates.²⁴ It should be emphasized that it is extremely important to be as accurate as possible when measuring capital and labor services, because any mistakes "migrate" to TFP, distorting its estimates.

In order to obtain TFP estimates it is still necessary to obtain the values of the parameters α and $(1-\alpha)$. Under the hypothesis of competitive markets, in which inputs are paid their marginal productivity, their values represent the share of capital and labor in income, and can be obtained directly from National Accounts data.

Recent data for Brazil indicate that labor participation is, approximately, equal to 51%. That is a low number when compared to several developed countries, but similar to those of other developing countries. For example, labor participation in income is,

²³ The participation rate is growing over time in Brazil, and have increased to 61% in 1999 from 53% in 1980. One of the main underlying factors behind this growth is the increasing number of women entering the labor force. Notice that this is a worldwide phenomenon and, in Brazil, there is no evidence that it has ended.

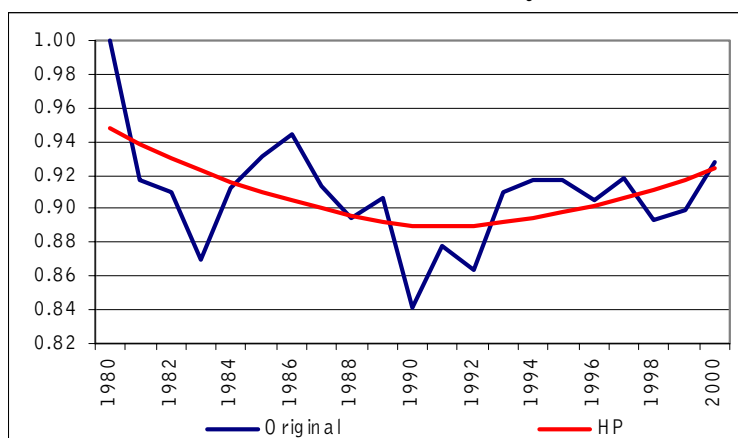
²⁴ In practice, only discrete data are available. In this case, TFP's growth rate is given by:

$$\Delta\% A_t = \frac{(1 + \Delta\% Y_t)}{(1 + \Delta\% L_t)^\alpha (1 + \Delta\% K_{t-1})^{1-\alpha}} - 1$$

approximately, equal to 68% in United States (Giorno et alli, 1995), 67% in Canada (Dion and Kuszczak, 1997), 70% in England²⁵, 46% in Argentina (Barro and Sala-i-Martin, 1999) and 48% in Chile (Barro and Sala-i-Martin, 1999).

Graph 2 shows how TFP has developed since 1980 in Brazil. In order to isolate its trend component, the Hodrick-Prescott filter was used.²⁶ As can be seen, in the last 20 years economy's aggregate productivity fell. However, in the nineties, more specifically, after 1992, this trend was reverted. In the 1980-1992 period TFP fell 0.7% on average, while in the 1993-2000 period its average growth rate reached 0.9%.²⁷ That is, in the last twenty years, TFP displayed two different phases, falling during the 80's and in the beginning of the 90's and growing ever since.

Graph 2
Total factor Productivity



In spite of this being, at first sight, a surprising result, other studies have found similar results for Brazil. Ferreira and Rossi (1999) found evidence, but just for the transformation industry, that TFP dropped in the second half of the eighties, and that the negative trend was reverted in the 90's. Bonelli and Fonseca (1998) report that, in the nineties, there was a reversion in the decelerating TFP growth observed in the eighties.²⁸

²⁵ See "Economic Models at the Bank of England", Bank of England (1999).

²⁶ To minimize the end of sample bias, TFP was projected until 2005.

²⁷ Notice that trend growth rates are smaller than geometric averages. Considering the former, in the 1980-1992 period, the TFP fell, on average, 0,67%, and in the 1993-2000 period, TFP grew, on average, 0,45%.

²⁸ It is worth noticing that the authors did not find negative rates for any year in the 1971-1997 period. In other words, PTF would have grown monotonically during the entire period, a phenomenon never found according to empirical studies. This result also contradicts evidence that productivity is pro-cyclical. Among others factors, this result is due to the fact that the authors have used potential output growth rates, instead of GDP growth rates, to calculate TFP, which is not the standard procedure.

Roldos (1997) shows that Chile's TFP has the same U-shaped pattern found here for the Brazilian economy. According to his estimates, between 1970 and 1985, the TFP of the Chilean economy fell, when the trend reverted. Moreover, according to Barro (1998): "The estimated TFP growth rates in Latin America are particularly low - typically negative - from 1980 to 1990 ". Reporting results found by Elias, Barro shows that the average TFP growth for Brazil in the 1940-1990 period is only 0,8%. Those evidences lead us to conclude that before 1980, the average TFP growth rate was larger than 0,8%. As a matter of fact, the decline of productivity when compared to its historical averages was a widespread phenomenon observed in several countries after the first oil shock, and is known as "the productivity slowdown". Even with the small TFP growth rate between 1940 and 1980, it is noteworthy that Brazil was one of the fastest growing countries in the world in that period: 6.4% per year.

It is difficult to ignore the coincidence between the reversion of the TFP trend in the early nineties and the opening of the Brazilian economy beginning in 1990.²⁹ That fact suggests that there might exist a relationship between openness and productivity growth. In fact, an increasing number of studies have been showing strong evidences that there is a positive relation between both factors.³⁰

The TFP fall is not an intuitive phenomenon, on the contrary, due to the fact that the variable "A" represents the technology in the Cobb-Douglas function, this is an odd result because, clearly, technology is improving over time. After all, if technological progress is evident in all areas (machines and equipment, computers, telecommunications, medicine, etc.), how does one explain this result?

The first part of the answer refers to the very definition and interpretation of the variable "A". Notice that, in spite of representing technology in the production function, the variable "A" is known as TFP. Even so the problem remains, as long as it is expected that productivity grows as technology improves. Another name that better shed light in what "A" measures, although it is less notorious and attractive, is "the measure of our ignorance ", because there are other factors besides capital and labor that matter for the

²⁹ Despite the fact that the trough of the TFP series occurred in 1990, when the opening economic process began, this coincidence is due to cyclical factors, as in that year the Brazilian economy faced the deepest recession ever, 4.35%.

³⁰ See, for example, Rossi and Ferreira (1999) for Brazil and Edwards (1997) for international evidence.

output level.³¹

A broad interpretation suggests that the variable "A" can be understood as the “society’s technology”, which represents a group of factors and conditions that contribute to a greater efficiency of the economic system. In fact, a more careful analysis of the Brazilian experience in the last twenty years shows that several factors may and probably have contributed adversely to the improvement of productivity, despite technological improvements.

The main suspect is the great macroeconomic instability experienced by the Brazilian economy after the 70’s. Many years of high chronic inflation, balance of payments crises and several stabilization plans (some including price controls), have caused several distortions in the relative prices system along with increasing uncertainty, harming economic efficiency.³²

Other factors that may also have been harmful to productivity growth are the absence of political-institutional stability, protectionism (mainly in the 80’s), a slow and inefficient legal system, a high corruption level and the decrease in infrastructure investments.^{33,34}

Corruption can be understood as a tax on investment that decreases its rate of return and has harmful allocation effects. By its turn, there is evidence that public investment is, in some degree, complementary to private investment. For Brazil, some studies found evidence that there is a causality between infrastructure investments and economic growth³⁵ Hence, it can be said that “society’s technology” worsened in Brazil during the last twenty years, by not creating a favorable atmosphere and the correct incentives for the efficient use and allocation of productive resources.

It is important to underline the fact that TFP is pro-cyclical, in spite of the corrections

³¹ Including inputs' measurement errors and inappropriate hypotheses regarding the “real” production function.

³² Bruno and Easterly (1997) found evidences that high inflation rates (above 40% according to the authors) harm economic growth.

³³ Tanzi and Davoodi (2000) found evidence that corruption is negatively correlated with per-capita GDP growth. One could easily claim that a possible channel through which this effect works is a decrease in economic efficiency, and therefore, productivity.

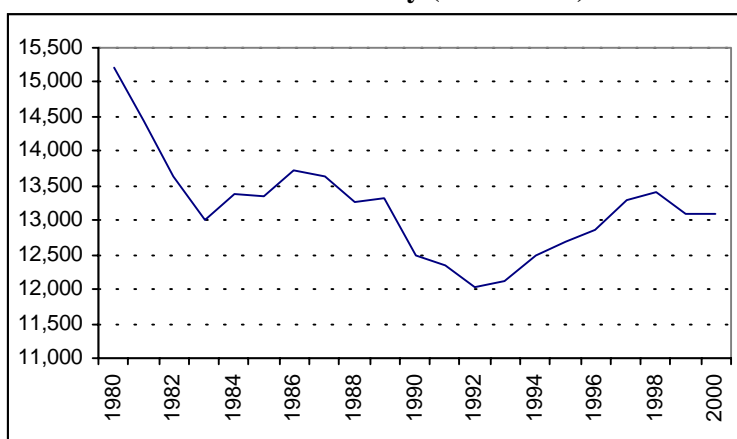
³⁴ According to International Transparency, Brazil was placed in 45⁰ place among 99 countries when compared as to the perception of corruption.

³⁵ See Ferreira and Malliagos (1995).

made for the intensity of the use of inputs. Among the main factors mentioned in the literature regarding this fact are the existence of growing returns to scale and the variable use of the factors of production along the economic cycle. The importance of this evidence is that one should be very careful before interpreting recent changes in productivity growth as being durable or permanent phenomena. Actually, changes in productivity trend can only be confirmed after some time. On the other hand, a failure to recognize those changes in due time can have, sometimes, disastrous effects for the conduct of monetary policy.³⁶ Certainly, this is not a comfortable situation for policymakers.

Graph 3 shows how has average output per worker, which represents a more restricted measure of productivity, labor productivity, evolved in Brazil.³⁷ There is a dual behavior since 1980. Labor productivity fell during the 80's and grew during the 90's. Note that this result is in line with the TFP development.

Graph 3
Labor Productivity (in R\$ 1999)



B) Sources of Growth in the Brazilian Economy

Table 1 shows how important were the contributions of capital, labor and of TFP for GDP growth, since 1980. Despite the slower input growth, the Brazilian economy grew

³⁶ This happened in the United States after 1973, when productivity experienced a slowdown. Until the Fed realized that the sustainable economic pace had decreased, it kept monetary policy at the same stance, which proved to be very expansionist when inflation began to rise, requiring a great increase in interest rates in the beginning of the 80's.

³⁷ It considers only employed workers. Note that if the entire labor force is considered, the drop would be much larger.

more during the decade of 90 than in the decade of 80.³⁸ This fact is explained, entirely, by TFP growth, in opposition to its drop in the decade of 80. Moreover, note that the increase in economic efficiency was responsible for, approximately, one third of the Brazilian economy growth during the decade of 90.

Table 1
Brazilian Economy: Sources of Growth³⁹

	Y	A	L	K
Decade of 80	1.56%	(1.74%)	1.80%	1.50%
		(111.23%)	115.20%	96.03%
Decade of 90	2.63%	0.97%	0.84%	0.82%
		36.98%	31.88%	31.13%
1980-1992	1.92%	(0.72%)	1.48%	1.16%
		(37.34%)	76.94%	60.40%
1993-2000	3.23%	0.88%	1.00%	1.35%
		27.34%	30.89%	41.78%

OBS: Bold numbers indicate contributions to economic growth.
Numbers between parenthesis means negative rates.

The last two periods of Table 1 were divided in accordance with the TFP trend reversion shown by the HP filter, which had took place after 1992. In this case, an important change in the sources of growth of the Brazilian economy in the last years can be seen. During the decade of 90 capital input overcame labor input as the main source of GDP growth, reflecting both the drop of the labor force growth rate and the interruption of the decrease in investment rates.

C) Potential Output Estimation

The potential output is determined replacing, in the production function, the inputs' potential or full employment levels, together with the TFP trend, as equation 12 shows.

$$\bar{Y}_t = \bar{A}_t \bar{K}_t^\alpha \bar{L}_t^{1-\alpha} \quad (12)$$

In order to determine the potential labor level (\bar{L}_t), it is necessary to know which is the natural rate of unemployment of the Brazilian economy. With that purpose, the average unemployment rate between 1980 and 2000, 5.5%, is assumed to be equal to the natural rate of unemployment. The potential level of labor is determined in the following way:

³⁸ The decades of 80 and 90 include the 1981-1990 and 1991-2000 periods, respectively.

³⁹ The rates of change refer to the logarithmic of the variables.

$$\bar{L}_t = \bar{LF}_t(1 - \bar{u}_t) \quad (13)$$

Similarly, in order to determine the potential capital stock level (\bar{K}_t) it is necessary to know which is the rate of capacity utilization compatible with the full employment of the capital stock. In this case, a different approach was adopted because, as anyone who is up-to-date to Brazilian economy during the last two decades knows, the 1980-2000 average capacity utilization rate, 79%, is clearly below full capacity.⁴⁰ In the decade of 70, when the economy grew 8,6% per year, the average rate of capacity utilization reached 86,5%. Analyzing the evolution of CU since 1970, 85% was chosen as representative of potential CU for the Brazilian economy. Therefore, the potential capital stock is given by:

$$\bar{K}_t = C * \bar{CU} \quad (14)$$

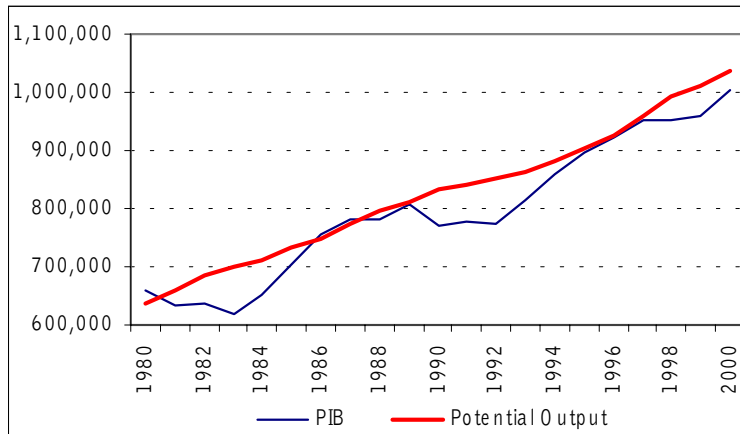
Graph 4 exhibits the development of Brazilian potential output in the 1980-2000 period, and Graph 5 shows the behavior of the output gap in the 1980-99 period. It is clear that, in most of the years, the Brazilian economy was below its potential. Only in three years, 1980, 1985 and 1986 the economy was above its potential. Among these, the year with the largest output gap was 1980, when the economy was almost 4% above its potential. In 1985 and 1986, the output gap was smaller, around 1%. Also, in 1989 and 1997 the output gap was practically zero.⁴¹ Finally, it can be observed that in the end of 2000 the Brazilian economy had idle capacity.

There is a propensity to associate those years showing stronger GDP growth with positive output gaps (or less negative). Notice, however, that although the probability is higher, there isn't a two-way relationship between them. The recessions that occurred in the beginnings of the 80's and 90 illustrate this fact. In 1981 and 1990, GDP fell 4.25% and 4.35%, respectively, however the smallest output gaps happened in 1983, -11.5%, and 1992, -9.7%. This fact can be explained, basically, by two reasons: first, the magnitude of the output gap in a given year depends on how strong economic activity

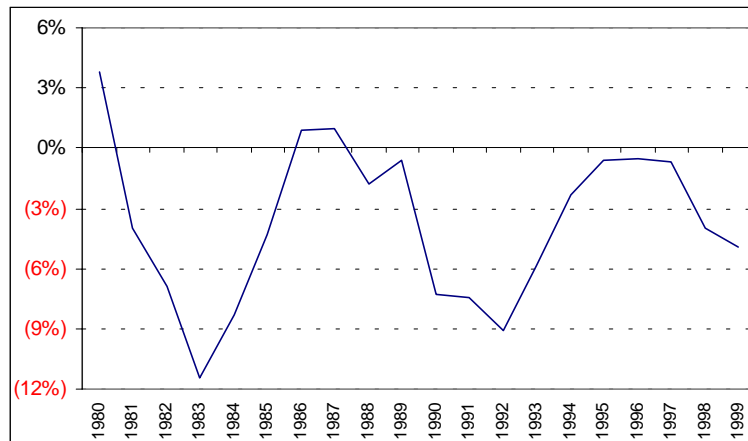
⁴⁰ In 2000 capacity utilization was, approximately, 83%, and the consensus is that the economy was not overheated. This is one evidence that the full employment capacity utilization is, probably, above this figure.

was in the previous year; second, it also depends on how the economy developed in the following year, vis-a-vis the potential output. After plunging in 1981, GDP fell again in 1982-83, augmenting even more the negative output gap. Similarly, if a strong growth year is followed by a year in which GDP grows more than potential, the positive output gap will increase (or the negative will decrease).

Graph 4
Potential Output (million R\$ 1999)



Graph 5
Output gap



⁴¹ As will be seen, these results are highly sensitive to the assumptions about the natural rate of unemployment and “full employment” capacity utilization. A rise in the former or a fall in the latter shift upward the whole potential output curve. However, its dynamic remains the same.

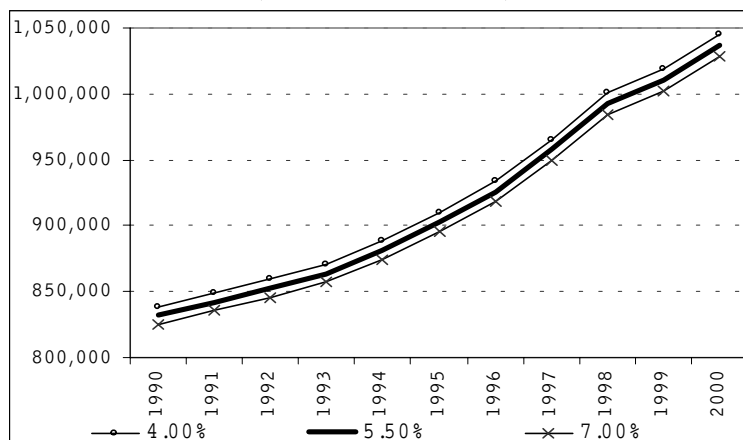
D) Uncertainties Regarding Potential Output Estimation

As mentioned before, potential output estimates involve a high degree of uncertainty. In addition to the fact that potential output is a non observable variable itself, it also depends on other non observable variables which are difficult to measure such as, for example, the unemployment rate and the capital stock depreciation rate. The effects of these uncertainties on potential output estimation can be divided in two groups. In the first, uncertainty affects the potential output level and, therefore, the output gap level. In the second, uncertainty affects the dynamic of potential output and, therefore, the output gap dynamic.

Graphs 6 and 7 show the effects of different assumptions regarding the unemployment rate (\bar{u}) and the “full employment” of capacity utilization (\overline{CU}) on potential output estimates, and compare the results with those stemming from the *default* assumptions used for the Brazilian economy: 5,5% for the natural rate of unemployment and 85% for full employment capacity utilization.

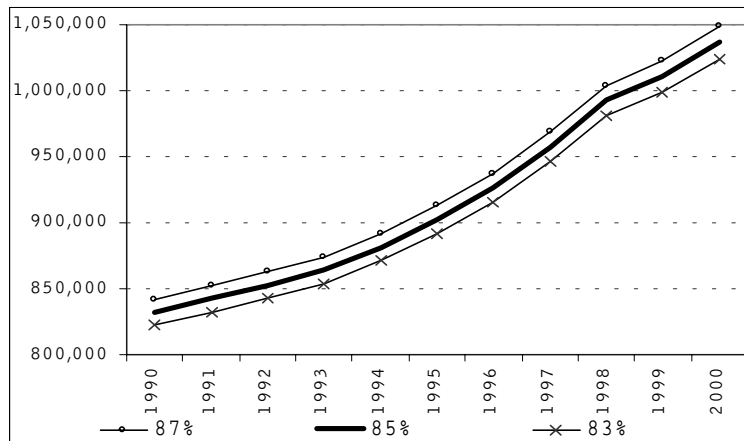
Graph 6 compares the potential output curve obtained when \bar{u} is equal to 5,5% to two other curves resulting from different assumptions: 7% and 4%. As it can be seen, if the natural rate of unemployment is 4%, the potential output curve shifts upward, while it shifts downward if the natural rate is 7%. Thus, there is a scale effect only.

Graph 6
Potential Output and the Natural Rate of Unemployment
(In millions R\$ 1999)



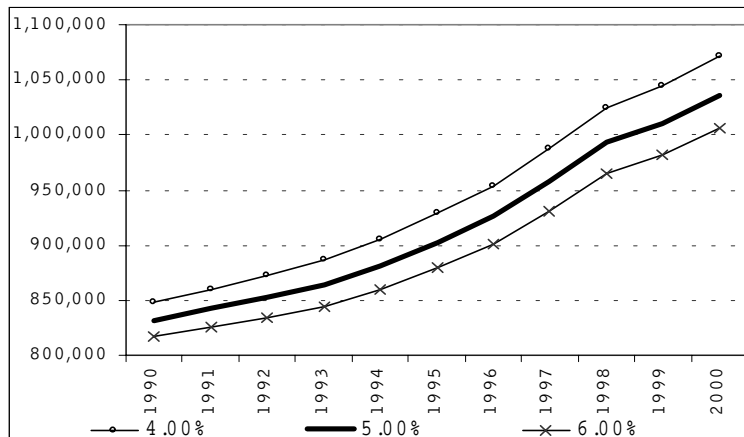
The same result holds in relation to the full employment capital stock, Graph 7, but the effect is the opposite. When full employment capacity utilization is increased potential output curve shifts upward. This happens because *ceteris paribus* an increase in full employment capacity utilization means a higher capital stock idle capacity, which is the same effect that happens to the labor market when the natural rate of unemployment decreases.

Graph 7
Potential Output and Full Employment Capacity Utilization
(In millions R\$ 1999)



Lastly, Graph 8 shows the effect of a different capital stock rate of depreciation (other than 5%) on potential output estimates. In opposition to the last two cases, the dynamic of potential output changes.

Graph 8
Potential Output and the Depreciation Rate
(In millions R\$ 1999)



4 - Potential Output: Scenarios and Projections

In the last ten years, the Brazilian economy has been experiencing deep structural changes motivated, mainly, by the process of economic opening initiated in 1990, and by the privatization process, which gathered pace since 1994. The first broadened internal competition, pushing national enterprises into a process of modernization, while the second factor provided access to new technologies. In both cases, the productivity gains are undisputed. Furthermore, the stabilization of the economy since 1994 increased the efficiency of the price system and decreased the level of uncertainty. Therefore it seems reasonable to expect an increase in TFP growth in the next years, consolidating the TFP trend reversion verified after 1992.

Hence, four different scenarios are assumed regarding TFP growth in the next five years: a) in the first, TFP grows at the same 1993-2000 average rate, 0,9%; b) in the second, TFP growth increases to 1.2%; c) in the third, TFP growth increases to 1,5% and; d) in the fourth, TFP growth increases even more, 1.8%.

Similarly, the assumptions for the investment rate are: a) 19.,5% in 2000, 20% in 2001, 20.5% in 2002; 21% in 2003 and 21.5% in 2004; b) 20% in 2000, 20.8% in 2001, 21.6% in 2002; 22.4% in 2003 and 23.2% in 2004, and; c) 20% in 2000, 21% in 2001, 22% in 2002; 23% in 2003 and 24% in 2004.⁴² Since potential output depends on the last period's capital stock, the scenarios do not include investment rate for 2005.

Regarding labor input, it is assumed that the labor force will grow at the same average rate of the 90's, 1,97%. This assumption also means that the participation rate will continue to grow, reaching 60,1% in 2005 from 59,2% in 2000. Table 2 shows the results for average potential output growth rates during the 2001-2005 period, according to each scenario considered.

Depending upon which group of assumptions are considered, potential output will grow between 3,3% and 4,59%, in the 2001-05 period. Even in the most optimistic scenario, potential output growth is below the GDP growth rates seen before 1980.⁴³ This result is

⁴² In 1999 prices. Note, once more, that these rates do not include inventories.

⁴³ In the decade of 70 average GDP growth was 8,6%.

due, basically, to the drop in the investment rates, particularly after 1982, as shows Graph 9.

Table 2
Potential Output 2001-05: scenarios and projections

		INVESTMENT*		
		Hip. 1	Hip. 2	Hip. 3
TFP	0,9%	3.3%	3.5%	3.6%
	1,2%	3.6%	3.8%	3.9%
	1,5%	3.9%	4.1%	4.2%
	1,8%	4.2%	4.4%	4.5%

(*) In 1999 prices.

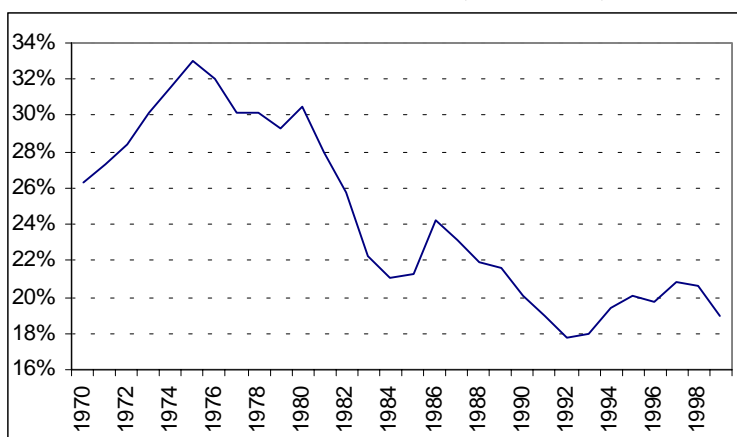
Hip.1 - FBCF equals 19,5% - 20%-20,5%-21%-21,5% em 2001-04, respectively.

Hip.2 - FBCF equals 20%-20,8%-21,6%-22,4% -23,2% em 2001-04, respectively.

Hip.3 - FBCF equals 20%-21%-22%-23%-24% em 2001-04, respectively

At 1999 prices, average investment rates peaked at 30% in the decade of 70, compared to 23% in the decade of 80 and 19% in the decade of 90. Even so, 3.3% which is the lower bound forecast, is well above the average GDP growth rates of the decades of 80 e 90.⁴⁴ However, even considering an increase in productivity, unless investment rates rise strongly in the next few years, the sustainable growth rate of the Brazilian economy should be far below what happened before 1980.

Graph 9
Real Investment Rates* (in R\$ 1999)



(*) Gross Capital Stock

It should be observed that the figures in Table 2 don't imply a speed limit for these

years. Since in the end of 2000 the economy had idle capacity, GDP can grow, according to the scenarios analyzed, between 3,9% and 5,2% per year in the 2001-05 period without overheating. The same situation occurred, for example, between 1993 and 1995, when average growth reached 5%, despite the fact that potential output growth was much smaller, around 2%, without demand pressure.

5 - Conclusions

Since potential output is an unobservable variable its estimates involve a high degree of uncertainty, as can be seen by the existence of several methods to estimate it. In this paper the traditional production function method was chosen because, beyond its intuitive nature, it has important advantages such as, for example, relating inputs to output. Additionally, as part of its determination, TFP estimates are obtained, which is a key variable in assessing economic efficiency and, therefore, a fundamental variable in determining sustained economic growth.

The results found for Brazil are, at first sight, surprising, since they show that TFP fell in the last twenty years; however, the declining trend was reverted in the 90's, more specifically, after 1992. The numbers show that TFP decreased, on average, 0,7% between 1980 and 1992, and increased 0,9%, between 1993 and 2000, on average.

It is argued that TFP should be interpreted as a proxy for the “society’s technology”, that represents a wide group of factors and conditions that contribute to a higher efficiency of the economic system. In fact, factors such as the chronic macroeconomic and political instability in the last twenty years and the fact that the economy was closed in the 80's, among others, help make this result more intuitive.

So, it is argued that the reversion of the TFP trend can be associated with the deep structural reforms which the Brazilian economy has been experiencing. Among them, the opening of the economy, begun in 1990, and the stabilization of the economy, since 1994, should be stressed. These factors have been providing an atmosphere of lower

⁴⁴ In the decades of 80 and 90 GDP grew, on average, 1.6% and 2.6%, respectively.

macroeconomic uncertainty and higher efficiency of the relative prices system. Hence, the growth rate of TFP is expected to increase in the next years, although some caution is required, because changes in the productivity trend can only be confirmed several years afterwards.

Concerning potential output, the results show that, in the 1980-2000 period, most of the time, the Brazilian economy was below its potential. The years of strongest economic activity were 1980, 1986 and 1987, when the economy was above its potential, and the years of 1989 and 1997, when the output gap was nearly zero. The most negative output gaps occurred in 1983 and 1992, two years after the deep recessions of 1981 and 1990. The results also show that in the end of 2000 the Brazilian economy was below its potential.

Additionally, based on different scenarios regarding investment and TFP growth rates, projections for the period 2001-05 were made. These projections show that potential output growth for the next five years should lie between 3.3%-4.5%.

These figures indicate that the sustainable economic growth rate of the Brazilian economy decreased strongly, when compared to the growth rates observed before the 80's. Even so, they are higher than the average growth in the last two decades. Notice, however, that due to the existence of idle capacity in the beginning of 2001, the economy can grow between 3.9%-5.2%, on average, in the next five years, depending on the preferred scenario, without causing any demand pressures.

Finally, the decrease in the sustainable rate of growth of the Brazilian economy can be explained, basically, by the strong drop in investment rates during the 80's and 90's. Therefore, if Brazil wants to grow at a rate near to its historical average, it is necessary to increase substantially investment rates in the following years, even considering an expected increase in TFP.

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