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Estimating Brazilian Potential Output: A Production Function Approach[1]

Tito Nícias Teixeira da Silva Filho[2]

Abstract

The estimation of potential output involves high degree of uncertainty. At the same time, it has great importance to policymakers, an unpleasant combination. This uncertainty fostered the creation of several methods to estimate potential output. In this paper, the production function approach was chosen because it has important advantages compared to other methods, 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 level. The years with the 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 lie 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, one can expect that TFP growth will increase in the next years. Even so, without a sharp increase in investment rates, Brazil will not grow at rates near 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"Until the laws of thermodynamics are repealed, I shall continue to relate outputs to inputs – i.e. to believe in production functions.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 decade of 1980 was characterized by the conjunction of two factors: a large 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 large influence on national economic literature, since long run issues gradually lost terrain among Brazilian economists' interests. Important issues, such as potential output estimation have not been in national economists' agenda since then, as shown by the small number of papers written about it. Nonetheless, 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 caused by the oil shocks in the 70's motivated, in a first moment, the emergence of papers analyzing why the growth rate of the Brazilian economy had fallen, and attempts to determine its potential output as well. However the inflationary disarray and the resulting recurrent macroeconomic instability attracted economists' attentions during the 80's and 90's. 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 economic stabilization plans.

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

Even though the Real Plan, implemented in mid-1994, was successful in reducing the inflation rate from 965% in 1994 to 1.65% in 1998, during that entire period there was a persistent concern regarding its vulnerabilities and, therefore, sustainability, putting aside 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 an 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 enormously wrong, as annual inflation in 1999 remained below 9%.

It can be said that 1999 was a unique year in the Brazilian economic history, not only because of the extremely successful transition to a flexible exchange-rate regime but, above all, by the recognition of the 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 issue of sustainable economic growth gained prominence quickly. As a consequence, in 2000, medium and long-term issues came again, after a long time, to the main agenda of economic and political debates. In this context, potential output estimation is a fundamental subject.

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 in the determination of the neutral real interest rate, and helps to assess the real stance of fiscal policy, since one needs it 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 forecasts, under alternative scenarios, are made for the period 2001-05. During that process, estimates of total factor productivity

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

(TFP) for Brazil, a fundamental variable to evaluate how fast the Brazilian economy can grow in the future, are also obtained. Lastly, the sources of growth of the Brazilian economy in the last twenty years will be determined, assessing the role played by labour and capital inputs 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 Brazilian economy's main sources of growth are determined. Following, the production function method is used to estimate the potential output and the output gap for Brazil for the 1980-2000 period. Finally, some simulations are carried out 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 papers written in Brazil about 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 papers 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 each year's 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 each year's capital stock 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 in which the GDP growth was the dependent variable and one-period lagged investment rate was the independent variable, besides the constant.[6] Then, a specific year was assumed as having zero output gap and, using the estimated regression, the potential output series for the entire period was built.

[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 forecasts for the 1983-1986 period.

Doellinger and Bonelli (1987) used a similar method to estimate potential output for the 1970-1986 period. However, the estimated equation had the potential output as 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. With that purpose, potential output was estimated isolating the trend component of the GDP and, later on, adjusting the resulting series so as to coincide with GDP in those years considered of full capacity utilization.

Carvalho (1996) estimated a reduced form of aggregate supply and demand curves in order to estimate 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 the 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 obtain productivity measures of the Brazilian economy, Bonelli and Fonseca (1998) used estimates of potential output *changes* for the 1973-97 period, 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 change 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. This means that the elasticity of substitution between capital and labour 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 both the level and the rate of change of the potential output. Fourth, it is necessary to assume that in a given year the output gap is zero. The output gap in the other years of the series is extremely sensitive to that assumption. Moreover, one should notice that, if in the future a given year happens to have a smaller capital to output ratio, then that year in the past which had been previously considered as having a zero output gap, will afterward show a negative gap instead. Clearly, 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 fitted a trend line through the peaks of the original series. Moreover, during the process, they assumed a constant potential output growth during the period under analysis.

Although the method used by Carvalho (1996) differs from the others for being more rigorous, it also has some limitations. For example, the method used 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 statistically non significant coefficients in the estimated equations. As a result of these and other limitations, which won't be discussed here, estimated depreciation rate reached, in some scenarios, negative values. Lastly, capital to output ratio proved to be very sensitive to the period considered.

3 - Potential Output and the Production Function

The estimation of potential output involves high degree of uncertainty. This is mainly due to the fact that it is not a directly observable variable. Moreover, potential output depends on variables that are also non-observable, such as the natural rate of unemployment and the rate of depreciation of the capital stock. As a result, several methodologies were created with this purpose, and there is no consensus which is the best method. This is not a comfortable situation, especially for policymakers, since the misperception about the magnitude of the output gap can worsen existent unbalances in the economy. Note that, uncertainty is more harmful the closer to full employment is the economy.

In this paper the production function method was chosen to estimate the potential output, since 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 happens if there is an increase in the amount of labour; 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 assumption about technology and can incorporate 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 changes in the social welfare system, unemployment benefits and workweek length; d) in spite of the high uncertainty associated to its estimation, potential output forecasts are simple and intuitive. The path of labour input is strongly correlated with population growth, which is an easily to forecast variable.[9] Additionally, the production function method allows enough flexibility so that policymakers can exercise their judgment about how the key variables will evolve and, therefore, affect growth. On the other hand, capital stock estimates carry considerable uncertainty.[10]

As equation (1) shows, it is assumed that the structure of the 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.

$$Y_t = A_t K_{t-1}^{\alpha} L_t^{1-\alpha} \tag{1}$$

where: Y is GDP, K represents capital services and L labour services, while A is the contribution of technology, in spite of the fact that it is called TFP. The exponents can

[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 when forecasting the labour force, such as changes in life expectancy and changes in the population profile. Anyway, since these changes occur slowly over time, the uncertainty is much smaller when compared to other used inputs or variables uses in other methods.

[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 to be constant, while the investment rate is relatively stable during short periods of time.

be interpreted, under certain conditions, as the capital and labour participation in income.

Although the traditional functional form of the Cobb-Douglas technology relates the current capital stock to current production, in practice it is necessary to make an adjustment. 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 the growth accounting technique. Note that, as potential output, TFP is an unobserved variable. In order to obtain correct TFP estimates, it is extremely important that the flow of services of capital and labour 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 using the Cobb Douglas production function.

A) Defining and Measuring Inputs

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

$$K'_t = (1-\delta)K'_{t-1} + I_t \qquad (2)$$

where: K' is the capital stock, I is the level of gross domestic fixed capital formation (GDFCF) and δ is the capital stock depreciation rate.[11]

Note that equation (2) can also be represented as:

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

$$K'_t = (1-\delta)^t K'_0 + \sum_{i=1}^{t} (1-\delta)^{t-i} I_i \qquad (3)$$

where: K'_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, since 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 the value of 3.1%.[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 this number is derived from a commonly used rule of thumb value for the variable (Jones, 2000). However, 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:

$$K'_0 = (1-\delta)^n K'_{-n} + \sum_{i=0}^{n-1} \left(\frac{1-\delta}{1+g} \right)^i I_0 \qquad (4)$$

[12] As pointed out earlier, estimates from Carvalho (1996) 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^o 4591, the capital stock 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.

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

$$K_0' = \frac{(1+g)}{(g+\delta)} I_0 \tag{5}$$

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 approximation because, among other things, it is based on the assumption 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 estimate of the initial capital stock. With this aim one needs a capital stock series that goes sufficiently backward in time so that, in the beginning of the period under analysis the initial capital stock has already been so depreciated, that the hypothesis regarding its initial value has little relevance. Therefore, the capital stock series 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, the longer the series the better the approximation, but due to data limitations this was not possible.[17]

Once the capital stock is obtained, it is essential to take into account changes in its intensity of use, otherwise its services will not be measured correctly. 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 does not measure the degree of use of the whole capital stock of the economy, but only that of the manufacturing industry. Thus, we have:

$$K_t = K_t' * CU \tag{6}$$

G

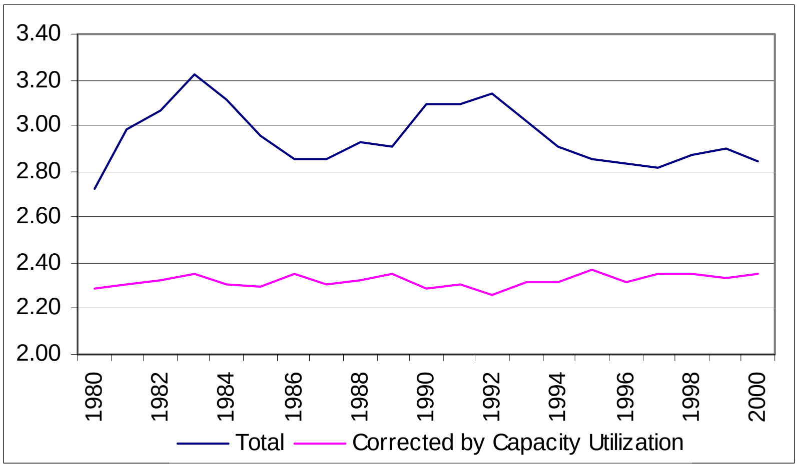
[15] In 1999 constant values.

[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 seems, 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 only 10%.

raph (1) exhibits some important results concerning the evolution of the capital to output ratio for the Brazilian economy. First, in the last twenty years this ratio has been oscillating around 3. In the beginning of the eighties and nineties it rose as a consequence of the 1981-83 and 1990-1992 recessions. During 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 the capital input, the uncertainties regarding labour input are much smaller. In this paper labour input (L) is represented by the labour force (LF); however, so as to the labour force reflects labour services appropriately, some important corrections should be made.[20] First, as it was done with capital input, it is necessary to take into account changes in the intensity of use of labour input. Second, it is necessary to understand the limitations of the labour 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]

[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 as the year estimate. This series is preferred because it encompasses a larger sample than the other two.
[19] At 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 labour services would be number of hours worked; however, due to data limitations, the number of workers in the labour force is used.

Changes in the intensity of labour use were taken into consideration by correcting the labour force by the unemployment rate (u). Since unemployed people do not contribute to production they should not be considered. Without these corrections, TFP estimates will be distorted. Another important point is that, due to the definition of labour force those who, by chance, don't seek for a job during the survey reference period won't be counted as part of the labour force, although they might be available and eager to work. That means that labour 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 economic recovery periods when, in a first moment, the unemployment rate increases instead of decreasing, since the number of people that join the labour force is greater than the number that get a job. Additionally, in certain occasions this peculiarity can provoke a fall in the labour force, an strange phenomenon that should be taken into account since it contradicts the fact that, usually, population grows over time.

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

$$r_t = \frac{LF_t}{WP_t} \tag{7}$$

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

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

$$L_t = \overline{LF_t}(1-u_t) \tag{9}$$

[21] Note that the labour force calculation methodology changed after 1991 with the broadening of the labour concept. Therefore, the published series after that date was corrected to become compatible with the old concept.
[22] This underestimation is larger during recessions because the incentive to look for work is weaker.

Therefore, the restrictions placed above prevent the labour force from being lower than in the previous year. That is an unusual phenomenon but, indeed, happened in 1996. In this case, the 1996 labour force was considered as being equal to the 1995 labour 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 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 behaviour 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 considering long periods of time, the labour force might not grow at the same rate as the population. Basically, that difference is possible due to changes in life expectation and socioeconomic conditions. These changes are reflected in the participation rate, which 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:

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

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 labour services, because any mistakes "migrate" to TFP, distorting its estimates.

In order to obtain TFP estimates one also needs to obtain the values of the parameters α and (1-α). Under the hypothesis of competitive markets, in which inputs are paid their

[23] The participation rate is growing over time in Brazil, and has increased to 61% in 1999 from 53% in 1980. One of the main factors behind this phenomenon is the increasing number of women joining the labour force. Notice that this is a worldwide phenomenon and, in Brazil, there is no evidence that the process has ended.

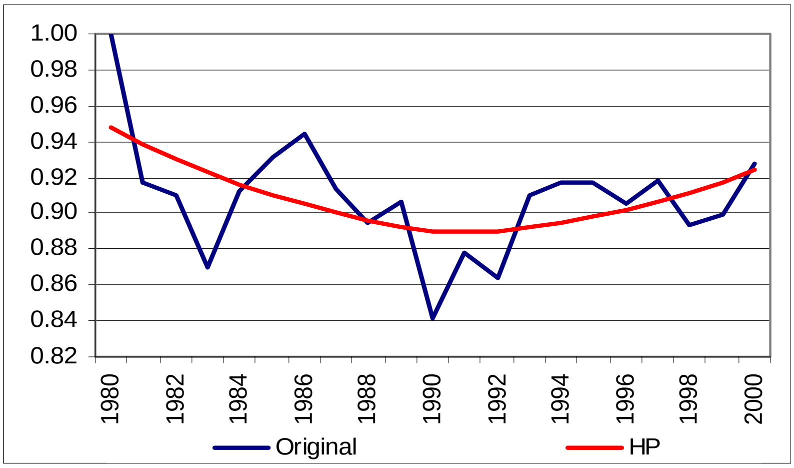
[24] In practice, only discrete data are available. In this case, TFP's growth rate is given by:

marginal productivity, their values represent the share of capital and labour in income, and can be obtained directly from the National Accounts data.

Recent data for Brazil indicate that labour participation is, approximately, equal to 51% of income. That is a low number when compared to several developed countries, but similar to those of other developing countries. For example, labour participation in income is equal, approximately, to 68% in the United States (Giorno et *alli*, 1995), 67% in Canada (Dion and Kuszczak, 1997), 70% in England[25], 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 evolved since 1980 in Brazil. In order to isolate its trend component, the Hodrick-Prescott filter was used.[26] As it can be seen, in the last 20 years the Brazilian economy's aggregate productivity fell. However, during the 90's, 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 has 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



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

[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%.

Despite being, at first sight, a surprising result, in some extent other studies have found similar results for Brazil. Ferreira and Rossi (1999) found evidence, though for the transformation industry only, that TFP decreased in the second half of the 80’s and that the negative trend was reverted in the 90's. Bonelli and Fonseca (1998) report that, in the 90’s, there was a reversion in the decelerating TFP growth observed during the 80’s.[28]

Roldos (1997) shows that Chile's TFP behaviour has the same U-shaped pattern found here, for the Brazilian economy. According to his estimates, between 1970 and 1985, Chilean economy’s TFP fell, and subsequently the trend was 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 Brazil’s average TFP growth rate during the 1940-1990 period was 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 decrease of productivity growth rates when compared to historical averages was a widespread phenomenon observed in several countries after the first oil shock, and it is known as "the productivity slowdown". Notice that, even with the small TFP growth rate between 1940 and 1980, Brazil was one of the fastest growing countries in the world during that period: 6.4% per year.

It is difficult to ignore the coincidence between the finding of a trend reversion in TFP behaviour in the early 90’s and the opening of the Brazilian economy, which began in 1990.[29] This fact suggests that there might be a relationship between openness and productivity growth. In fact, an increasing number of studies have been showing evidences that there is a positive relation between both factors.[30]

[28] It is unusual and worth noticing that the authors did not find negative growth rates for any year during 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 the well known 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 estimate TFP, which is an odd procedure.

[29] Despite the fact that the trough of the TFP series occurred in 1990, when the opening economic process began, one should be aware that this coincidence is due to cyclical factors, since in that year the Brazilian economy faced the deepest recession ever, a 4.35% fall.

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

The TFP fall is not an intuitive phenomenon, on the contrary, since the variable “A” represents technology in the Cobb-Douglas function. Therefore, 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 usually known as TFP. Even so, though, the problem remains since one expects that productivity grows as technology improves. Another name that in a better way sheds light in what “A” really measures, although it is less notorious and attractive, is "the measure of our ignorance ", because there are other factors besides capital and labour that matter for the output level.[31]

A broad but probably more correct 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]

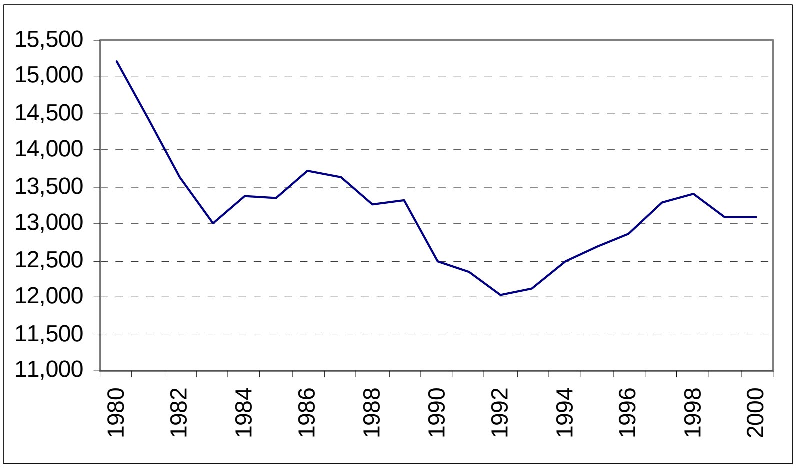
Other factors that may also have been harmful to productivity growth are the absence of political-institutional stability, protectionism (mainly in the 80’s), a slow and inefficient legal system, a high corruption level and the decrease in infrastructure investments.[33,34]

[31] Including, for instance, 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.

Corruption can be understood as a tax on investment that decreases its rate of return and has harmful allocation effects. Also, there is evidence that public investment is, in some degree, complementary to private investment. For Brazil, some studies have found evidence that there is causality between infrastructure investments and economic growth[35] Hence, it can be said that "society's technology" worsened in Brazil during the last twenty years, by not creating a favourable atmosphere and the correct incentives for the efficient use and allocation of productive resources.

It is important to emphasize the fact that TFP is pro-cyclical, in spite of the corrections 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 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
Labour Productivity (in R$ 1999)



[34] According to International Transparency, Brazil was placed in 45^0 place among 99 countries when compared as to the perception of corruption.
[35] See Ferreira and Malliagros (1995).
[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.

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

B) Sources of Growth in the Brazilian Economy

Table 1 shows how important were the contributions of capital, labour and TFP for GDP growth, since 1980. Despite the slower input growth, the Brazilian economy grew 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 Growth[39]

	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 parentheses mean negative rates.

The last two periods in Table 1 were divided in accordance with the TFP trend reversion shown by the HP filter, which have taken 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 labour input as the main source of GDP growth, reflecting both the drop in the labour force growth rate and the interruption of the decrease in investment rates.

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

C) Potential Output Estimation

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

$$\overline{Y}_t = \overline{A}_t \overline{K}_t^{\alpha} \overline{L}_t^{1-\alpha} \tag{12}$$

In order to determine the potential labour level ($\overline{L}_t$), 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 labour is determined in the following way:

$$\overline{L}_t = \overline{LF}_t (1-\overline{u}_t) \tag{13}$$

Similarly, in order to determine the potential capital stock level ($\overline{K}_t$) 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 the potential CU for the Brazilian economy. Therefore, the potential capital stock is given by:

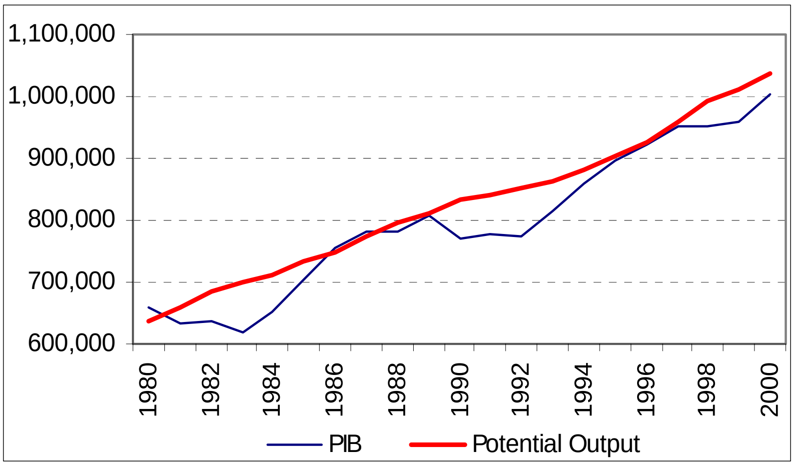
$$\overline{K}_t = K_t^{*} * \overline{CU} \tag{14}$$

Graph 4 exhibits the development of Brazilian potential output in the 1980-2000 period, and Graph 5 shows how the output gap evolved during 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

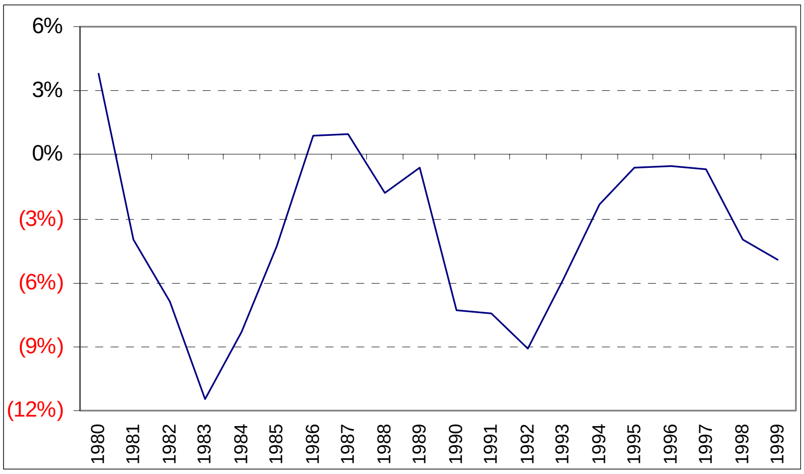
[40] In 2000 capacity utilization was, approximately, 83%, and the consensus is that the economy was not overheated. This is an indication that the full employment capacity utilization is, probably, above this figure.

potential. In 1985 and 1986, the output gap was smaller, around 1%. Also, in 1989 and 1997 the output gap was practically equal to zero.[41] Finally, it can be observed that in the end of 2000 the Brazilian economy had idle capacity.

Graph 4
Potential Output (million R$ 1999)



Graph 5
Output gap



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 is not 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, -

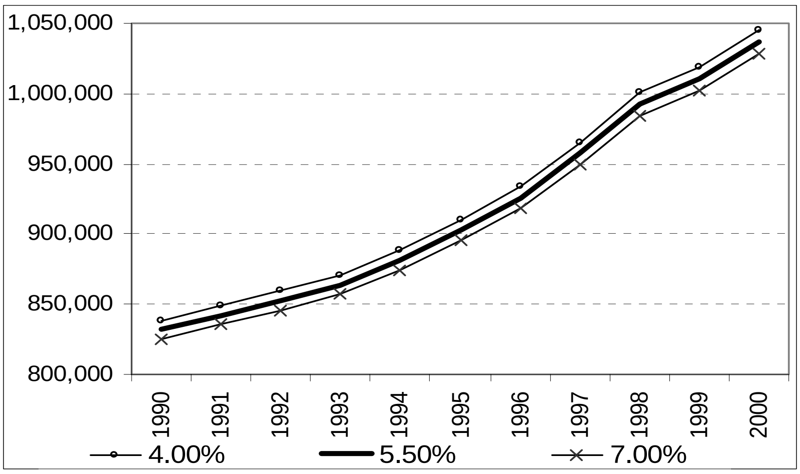
[41] As it will be seen, these results are highly sensitive to the assumptions about the natural rate of unemployment and "full employment" capacity utilization. A rise in the former or a fall in the latter shift upward the whole potential output curve. However, its dynamic remains the same.

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 was in the previous year; second, it also depends on how the economy developed in the following year, vis-à-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).

D) Uncertainties Regarding Potential Output Estimation

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

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

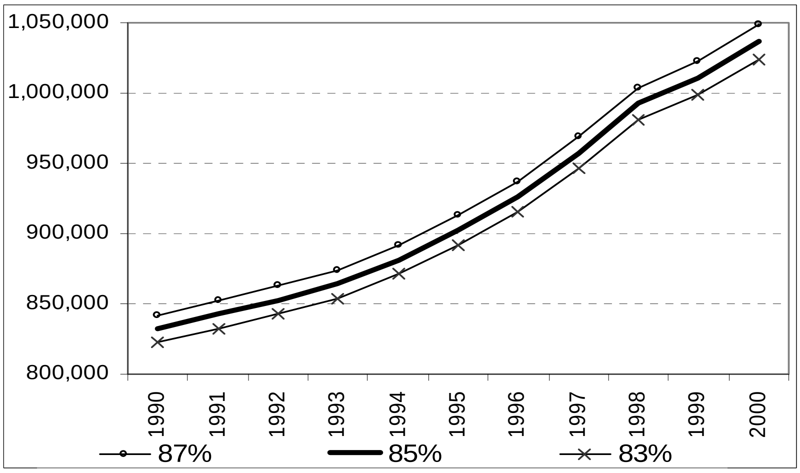


Graphs 6 and 7 show the effects of different assumptions regarding the natural unemployment rate ($\overline{u}$) and the "full employment" capacity utilization ($\overline{CU}$) on potential output estimates, and compare the results with those obtained from the initial assumptions used for the Brazilian 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 if the natural unemployment rate is 7% it shifts downward. Thus, there is a scale effect only.

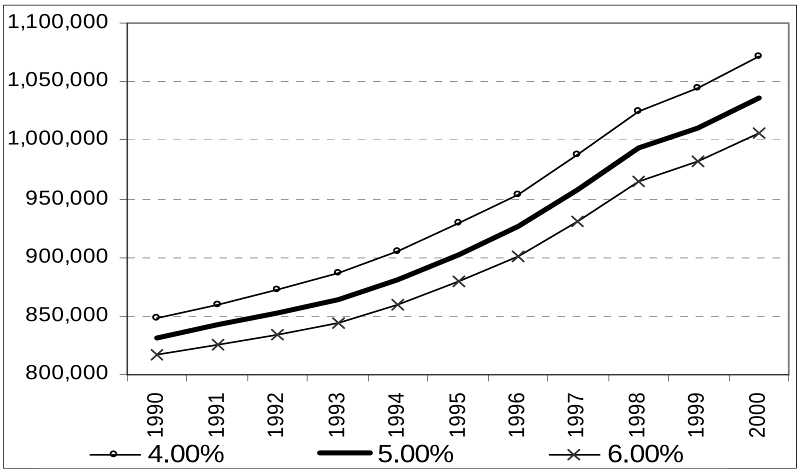
The same result holds in relation to the full employment capital stock, Graph 7, but the effect is the opposite. When full employment capacity utilization is increased potential output curve shifts upward. This happens because *ceteris paribus* an increase in full employment capacity utilization means a higher capital stock idle capacity, which is the same effect that happens to the labour 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. On the contrary 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

During the last ten years, the Brazilian economy has been experiencing deep structural changes motivated, mainly, by the opening economic process initiated in 1990, and by the privatization process, which gathered pace since 1994. The first broadened internal competition, pushing national firms into a process of modernization, while the second provided access to new technologies. In both cases, the productivity gains are undisputed. Furthermore, the stabilization of the economy since 1994 have 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] Notice that, since potential output depends on the last period's capital stock, the above scenarios do not include investment rate for 2005.

Regarding labour input, it is assumed that the labour 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 4,5% 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 due, basically, to the drop in 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%

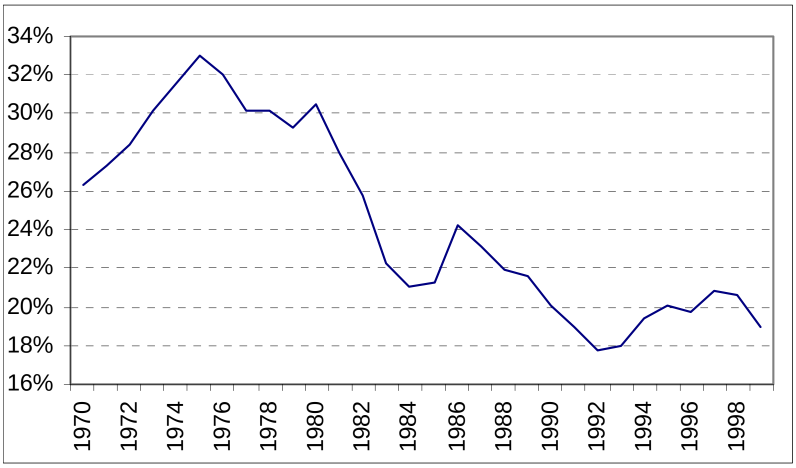
(*) In 1999 prices.
Hip.1 - GDFCF equals 19,5% - 20%-20,5%-21%-21,5% in 2001-04, respectively.
Hip.2 - GDFCF equals 20%-20,8%-21,6%-22,4% -23,2% in 2001-04, respectively.
Hip.3 - GDFCF equals 20%-21%-22%-23%-24% in 2001-04, respectively

In 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.

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

Graph 9

Real Investment Rates* (in R$ 1999)



(*) Real Gross Domestic Fixed Capital Formation

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 above, 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 production function method was chosen because, beyond its intuitive nature, it has important advantages such as the fact that it relates inputs to output. Additionally, as an important part of its estimation 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.

Here, 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 Brazilian 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 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 rates 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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