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TEMA: "THE TIME SERIES BEHAVIOR OF BRAZILIAN REAL CROSS DOMESTIC PRODUCT, 1947-1987: AN ANALYSIS OF INTERVENTIONS"
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Summary

The evolution of Brazilian real gross domestic product in the post-World War II period has been far from stable. Some of this instability is almost certainly due to the impacts of external shocks. In this paper we examine three such shocks, or interventions, which seem to have had particularly pronounced impacts on the Brazilian economy. These are the political upheavals and attendant economic reforms of the early 1960's, and the oil shocks of 1973 and 1979. We build a time series model, which permits the analysis of interventions, for annual Brazilian real gross domestic product, and use this model to estimate the impacts of these interventions.

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1. INTRODUCTION

In this paper we build and analyze a time series model for Brazilian real gross domestic product for the years 1947 to 1987. These data are graphed, in logarithmic form, in Figure 1. Even a casual look at this graph strongly suggests a lack of stability over this time period. Such instability can result from external shocks, or interventions, to the system. An approach, called intervention analysis, to model building for time series of this sort was proposed by Box and Tiao (1975), and has subsequently been exploited in many fields. This methodology, which essentially involves the incorporation of dummy variables into a time series model, is followed in spirit in our paper. In time series, external shocks can impact in a number of different ways, and some experimentation is desirable in developing an appropriate model specification. Once a satisfactory model has been achieved, estimates of the quantitative impacts of interventions can be computed.

Although every year might be regarded as in some sense "special," any formal model building necessarily requires the analyst to be somewhat conservative in identifying periods of intervention. In this paper we consider three possible serious shocks to the Brazilian economy. These are:

(i) The political upheavals and attendant economic reforms of the early 1960's. To develop a specific model, we date these in 1962.


Chapters 5 and 6 of Baer (1989) provide an extensive discussion of the political economy of the relevant time periods. These cover respectively the years 1960-73 and 1973-85. In the early 1960's the Brazilian economy entered a period of relative stagnation. During this period of political instability and pressures for social reforms, there was a lack of consistent economic policies to control the government deficit and halt the inflationary process. There was a decline in foreign and domestic investment, the former due in part to formal restrictions on foreign participation. Most analysts believe that by this time the Import Substitution Industrialization process, introduced in the 1950's, had lost its momentum. These years were followed by the so-called "miracle" period of 1968-73, when the Brazilian economy experienced rapid growth, made possible by excess domestic capacity, a booming international economy, and easy access to world capital markets (Fishlow 1985).

By October 1973, when the first oil crisis hit, Brazil was the largest third world oil importer. The subsequent deterioration in the terms of trade and the recession in developed countries led to changes in Brazilian economic policies, but a growth strategy was permitted by excess liquidity in the international financial system which allowed heavy borrowing (Barzelay 1986, Husain 1989). Brazil's Second National Development Plan was launched in December 1974. This plan aimed at providing self-sufficiency in two major sectors--capital goods and energy. (A detailed analysis of this plan is provided by Baer (1989), Fishlow (1985), and Araujo (1987).) When the second oil crisis occurred in 1979, Brazil's position was quite different. By the early 1980's,
Brazil had become the largest debtor in the developing world, and no longer had access to external financing to support economic growth. Thus, although, as Fishlow (1985) notes, the impact of the second oil shock on Brazilian growth was delayed somewhat, it could be expected to be quite different from that of the first shock. Balassa (1980) and Balassa and McCarthy (1984) provide further discussions of the adjustments of the economies of developing countries, including Brazil, to the two oil crises.

For many years, in part because of extensive empirical evidence presented by Nelson and Plosser (1982), received wisdom has been that the levels of economic time series follow, in the terminology of Box and Jenkins (1970) and Granger and Newbold (1986), integrated processes. Models fitted to such time series have typically had unit autoregressive roots, implying the need for differencing to induce stationarity, rather than fixed deterministic trend terms. However, a recent article of Perron (1989) presents evidence against the unit autoregressive roots hypothesis when interventions are incorporated into time series models. The models achieved by Perron include deterministic trend terms, and we will allow for this possibility in our analysis, which is motivated in part by Perron's work.

2. AN INTERVENTION MODEL FOR BRAZILIAN REAL GROSS DOMESTIC PRODUCT

Our time series data consist of annual observations on Brazilian real gross domestic product for the years 1947 to 1987. We analyze the logarithms of these data, denoting them by $y_t$. The possibility is allowed for three interventions, in the years 1962, 1973, and 1979, by
incorporating dummy variables into the time series model. These interventions could take a number of forms, and rather than assuming a specific form a priori, we allow three possibilities, which might occur separately or in conjunction with one another. In the context of a model with a linear trend, we consider "intercept," "slope," and "transient" effects of interventions, represented by dummy variables denoted DI, DS, and DT. Specifically, for the 1962 intervention, we define the three dummy variables D62I, D62S, D62T, such that

\[
D62I = D62S = D62T = 0 \text{ for all years up to 1962}
\]
\[
D62I = 1 \text{ for all years from 1963 on}
\]
\[
D62S = h \text{ for year } (1962+h), \ h = 1, 2, 3, \ldots
\]
\[
D62T = 1 \text{ for 1963, and 0 for subsequent years}
\]

In an obvious notation, we define the same three types of dummy variables for both the 1973 and 1979 oil shocks.

Our general model for the time series behavior of the logarithms of Brazilian real gross domestic product is similar to those considered by Perron (1989) for the levels of growing economic time series. We begin with the general form

\[
y_t = \alpha \cdot \beta t + \gamma y_{t-1} + \delta_{1,t} D62I_t + \delta_{2,t} D62S_t + \delta_{3,t} D62T_t
\]
\[
+ \delta_{4,t} D73I_t + \delta_{5,t} D73S_t + \delta_{6,t} D73T_t
\]
\[
+ \delta_{7,t} D79I_t + \delta_{8,t} D79S_t + \delta_{9,t} D79T_t
\]
\[
+ \omega_1 y_{t-1} + \omega_2 y_{t-2} + \epsilon_t
\]

The terms in lagged changes of the dependent variable are included to attempt to mop up any autocorrelation, so that the error term \( \epsilon_t \) should
behave as white noise. Under the hypothesis of unit autoregressive roots in the process generating the time series, the parameter $\gamma$ should be equal to one; in that case, the slope parameter $\beta$ is typically zero.

The general model (1) involves fourteen unknown parameters, which is uncomfortably many given a relatively short record of observations. Certainly this model violates the usual time series analysis prescription of parsimony in parameterization. This general formulation is initially proposed so as not to pretend to have too much prior information about either the autocorrelation structure of the time series or the form taken by the intervention impacts.

Our analysis of the Brazilian real gross domestic product series was aimed at finding a special case of the model (1) that appeared to be compatible with the data. Thus, after fitting the full model (1), we tried also various sub-models, dropping those terms whose parameter estimates had low significance. We checked whether, taken as a group, the set of variables deleted in this way had statistically significant impact. In addition, various candidate sub-models were compared through the AIC and SBC information criteria. As a result of this analysis we achieved the following preferred model:

$$Y_t = 4.727 + 0.0247 t + 0.665 Y_{t-1} - 0.0946 D62I_t \\
(0.760) (0.0041) (0.055) (0.0179)$$

$$+ 0.00940 D62S_t - 0.0136 D73S_t - 0.0861 D79I_t \\
(0.00224) (0.0036) (0.0255)$$

$$+ 0.107 D79T_t + \epsilon_t \\
(0.027)$$
Figures in parentheses below the coefficient estimates are the corresponding estimated standard errors. We found no significant evidence of autocorrelation in the error terms of this equation through the Durbin h-test. The estimated coefficient on the lagged dependent variable in the fitted model (2) differs from one by 6.09 standard errors, which on comparison with tables in Perron (1989) appears to present strong evidence against the unit autoregressive roots hypothesis, as does the significant slope parameter estimate. Perron’s study, and specifically the tables of significance points given there, is restricted to the case of a single intervention. When, as in our study, more than one intervention is permitted, comparison of the t-statistic on \( \gamma \) with Perron’s tables is not strictly valid. In fact, increasing the number of interventions will increase the critical value of the test statistic. Thus, while our result here can be viewed as suggestive, it does not provide the basis for a formal test of the unit autoregressive root hypothesis. This is not our goal. Rather, we are attempting to estimate the impacts of the interventions. In this context, it should also be added that, if the true generating process contains a unit root or a large autoregressive root, the least squares estimate of \( \gamma \) in (2) will be biased downwards. In consequence, our estimates of the magnitudes of the impacts of the interventions on Brazilian real gross domestic product may be somewhat conservative.

Terms in lagged changes of the dependent variable do not significantly improve the fit of (2). As a slight variant, we tried adding one and two lags in the dependent variable, but again with no significant improvement in fit resulting. Also, we deleted from (2) the...
lagged dependent variable and allowed the error term to follow particular low order autoregressive moving average models. However, the models achieved in this way fitted the data less well than (2). After this much experimentation, we feel it reasonable to conclude that the model (2), while not too heavily parameterized, provides a good description of the historical record of Brazilian real gross domestic product in the period under study.

We now proceed to explore the implications of the fitted model (2). Specifically, we want to estimate the impacts of the three interventions on Brazilian gross domestic product over a few years following those interventions. To do this, we express intervention-driven trend gross domestic product as a percentage of what trend gross domestic product would have been in the absence of interventions. To illustrate these calculations, consider the general model (1), concentrating on the 1962 intervention, and assuming (as is the case in our fitted model (2)) that \( \omega \) and \( \omega_2 \) are both zero. Then, taking into account the effect of the lagged dependent variable in (1), the impact of the intervention on trend logarithmic gross domestic product for year \((1962+h)\) is

\[
\text{INT62}(h) = \delta_{1,1}(1+y+\ldots+y^{h-1}) + \delta_{1,2}[h+y(h-1)+\ldots+y^{h-1}]
+ \delta_{1,3}y^{h-1}; \quad h = 1, 2, \ldots
\]

Then, intervention-influenced trend gross domestic product as a percentage of trend gross domestic product in the absence of the intervention is

\[
\% \text{ Impact}(h) = 100 \exp[\text{INT62}(h)]
\]
since \( y_t \) is the logarithm of gross domestic product. We calculated these percentage impacts for the three interventions for the first five years following the interventions. The results are shown in Tables 1-3. For example, in Table 1 it is estimated that in 1964 Brazilian real gross domestic product was 87.6\% of what it would have been that year in the absence of the 1962 intervention.

When traced out in Tables 1-3, we see that the three interventions had quite different impacts, both qualitatively and quantitatively, on Brazilian gross domestic product. It is the incorporation of different types of dummy variables into the model that permits the discovery of these qualitative differences. From Table 1, we see that the political upheavals and economic reforms of the early 1960's had a very severe and abrupt initial negative impact. By 1964, trend gross domestic product was only 87.6\% of what it otherwise would have been. However, from that point on the position deteriorated very little until, by 1967 the trend had begun to reverse. In terms of our fitted model (2), these findings reflect the positive coefficient on the slope dummy D62S. It appears that the negative impact of the 1962 intervention was fully incorporated into Brazilian real gross domestic product by 1965-7. In the following few years, as can be seen from Figure 1, the Brazilian economy enjoyed a period of rapid and sustained growth. This era is often described as the "miracle years." We do not claim that the "miracle" period was caused by the 1962 intervention. Indeed, as is clear from Table 1, the events of the early 1960's produced an initial dramatic slowing of the Brazilian economy. Nevertheless, it is possible that at least some of these events provided a foundation that allowed for the higher growth
rates, from a lower base, that were to follow in the "miracle years."

We have, however, truncated the results in Table 1 at 1967 precisely to avoid the implication that the later "miracle" period was a direct consequence of the 1962 intervention.

The 1973 Gil crisis may have ended the "miracle," but did not preclude quite respectable growth in Brazilian real gross domestic product. For example, we see from Table 2 that, even by 1977, trend gross domestic product had fallen by less than 10% of what it would have been in the absence of the first oil shock. This is not at all an unsatisfactory performance when it is kept in mind that the base intervention-free gross domestic product figures embody a projection of the high growth rates of the "miracle" years, through the term D62S in our model (2). Looked at solely on this basis, the performance of the Brazilian economy in reaction to the 1973 oil shock was quite satisfactory. However, our analysis reflects only the levels achieved by gross domestic product, and takes no account of how this performance was made possible. As we have already noted, continual expansion of the Brazilian economy in these years was made possible in part through heavy external borrowing. It is difficult to know the extent to which this strategy could have been sustained or that continued economic growth could have led to adequate debt servicing.

Whatever the case, it seems clear that the second oil shock, in 1979, precipitated a sharp deterioration, though it did not do so immediately. As Fishlow (1985) and others have suggested, the impact of the 1979 shock was delayed. Brazil continued to attempt a policy of high growth, funded by more external debt, but this policy could not be
sustained for long. In Table 3 we show 1980 gross domestic product 2.1% above the intervention-free trend value. We do not wish to imply that the 1979 oil crisis caused higher gross domestic product in the following year. This figure might instead be taken as reflecting the continued success of the borrowing strategy. Statistically, it arises from the positive coefficient on the transient dummy variable D79T in equation (2). Graphically, the same phenomenon can be viewed quite clearly as a "blip" in Figure 1. After 1980, it can be seen from Table 3 that the position worsens quite dramatically, so that by 1984 trend gross domestic product is only 81.7% of the intervention-free level—a level which itself reflects the deterioration induced by the 1973 shock, through the term D73S of equation (2). It seems quite clear from our results that the 1979 oil shock had a more severe impact on the Brazilian economy than did the 1973 shock, or the events of the early 1960's. It seems that the already heavily indebted economy was ill-prepared to face this shock, one of whose consequences was an eventual sharp curtailment in international borrowing.

3. SUMMARY

In this note we have attempted to write a statistical history of Brazilian gross domestic product in the post-World War II years. Our approach, which we believe is broadly applicable to a range of economic time series, is a compromise between an exclusively institutional study and a naive statistical one which takes no account of important institutional factors. A purely institutional study would provide little sound basis for numerical estimates of the impacts of important events. To do so requires a formal model such as (1) or (2) so that
results are not contaminated by random events $\varepsilon_t$. On the other hand, it is quite clear from the study of the progress of economic variables in developing countries that a picture such as Figure 1 will often emerge. Such pictures obviously do not reflect table patterns, but rather result from important institutional interventions whose impacts need to be analyzed.

Our analysis of Brazilian real gross domestic product develops a generally applicable methodology for estimating the impacts of interventions. To implement such a formal analysis it is important to take care in specifying individual intervention points. It is also very useful to verify the formal statistical results through graphical inspection. As we have indicated, our findings in this case accord qualitatively with the picture of the historical record presented by Figure 1.

We postulated three interventions in the evolution of Brazilian gross domestic product, and obtained numerical estimates of their impacts. The 1962 intervention led to a sharp quick drop in trend gross domestic product, followed by a recovery in the "miracle" years. The impact of the 1973 oil crisis was on trend growth rate. The high growth rates of the "miracle" years were reduced somewhat, but nevertheless economic performance, by this measure, was quite respectable. The effect of the 1979 oil crisis, though delayed for a year, was more severe. The heavily indebted Brazilian economy entered in subsequent years a period of relative stagnation, which has led to increased difficulty in servicing the huge external debt.
A methodological by-product of our analysis has been to lend
further empirical support to the findings of Perron (1989). If one
looks at this time series alone, it presents strong evidence of unit
autoregressive roots. However, when the intervention terms are included
in the model, the data provide some support for the hypothesis of
stationary variation around a fixed trend. We suspect that such a
phenomenon may occur quite commonly; it is one whose appropriate
analysis and interpretation warrants further study. However, it should
be reiterated that, because our model involves three interventions, our
results do not provide a formal test of the unit root hypothesis.
REFERENCES


TABLE 1: Percentage impact on Brazilian real G.D.P. of the 1962 intervention

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TABLE 2: Percentage impact on Brazilian real G.D.P. of the 1973 intervention

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TABLE 3: Percentage impact on Brazilian real G.D.P. of the 1979 intervention

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FIGURE 1: BRAZILIAN REAL GDP (1947–87)
in logarithms
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