Persistence of Innovations and Economic Policy: The Brazilian Experience

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I am especially thankful to William Maloney for his careful readings of several earlier drafts and insightful suggestions. Also, thanks go to Ana Dolores Novaes and Carlos Brandão Cavalcanti for their helpful comments. I benefitted from conversations with Paul Newbold as well. The usual disclaimers apply.

‡ From the Ph.D. Program in Economics at the University of Illinois at Urbana-Champaign.
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Francisco Cribari-Neto*‡

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- Abstract -

According to the conventional view, shocks in output have effects on the short-run, but are not persistent in the long-run. However, it has been argued in the recent literature that shocks in output do have long-run effects. This paper utilizes a nonparametric technique in order to check whether innovations in Brazilian GDP are persistent. We find that an innovation of one percent today is more than proportionately incorporated in the long-run, and we call this situation shock dominance. We also examine whether economic policies can alter the persistence of shocks. Our results indicate that on some occasions stabilization policies do have long-run effects.

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I. Introduction:

One of the most controversial questions in Macroeconomics is the one related to the persistence of innovations in long-run GDP (Gross Domestic Product). The more conservative view is the one related to deterministic trend-cycles decomposition. According to this view, product movements can be separated into two different components, trend and cycles, where the first one follows a deterministic path and the second obeys some stationary stochastic process.

This view has been challenged since the publication of the Beveridge and Nelson (1981) and Nelson and Plosser's (1982) influential papers. According to their understanding, the output trend itself follows a stochastic process. Although both cases do not seem very different, the implications of the stochastic trends are far-reaching.

Among these implications, four can be highlighted. The first one is related to the permanence of innovations. Unlike the deterministic case where innovations are temporary, in the second scheme we can have a high degree of permanence of shocks in the current product. Campbell and Mankiw's results (1987) indicate that an innovation of one percent in the present output is incorporated by more than one percent in the long-run output level.

The second important implication is related to the relationship between short and long-run policies. According to the traditional view, stabilization policies do not have long-run effects, while the second understanding implies that non-anticipated policies do have effects on the long-run behavior of the product. Roughly speaking, this means that economic agents are forced to live with the effects of unsuccessful stabilization policies in any period of time.

Thirdly, there is the issue of measurement of cycles. The traditional view tends to overestimate the cyclical component once any stochastic movement is attributed to it, as shown by Cuddington and Urzúa (1989) for the Colombian case.

Finally, if the trend in output is stochastic and one detrends the data assuming that it is deterministic some spurious patterns
are introduced. In particular, the autocorrelation function from detrended data may show pseudocyclical movements, as shown by Nelson and Kang (1981). Moreover, one is also limiting uncertainty, reducing the original variance of data, and reducing the influence of past over the future. This point is particularly important since detrending variables before the analysis or including time as an explanatory variable in regressions seems to be a common practice in applied works.

In the present paper we shall try to answer the following question: To what extent are the innovations in the Brazilian GDP persistent? We shall argue that, based on our results, this permanence occurs to a high degree. Next, we try to establish a connection between persistence of innovations and economic policy. With this aim we analyze the Brazilian experience after the first international shock in oil prices.

The rest of the paper is organized in the following way. Section II briefly discuss some of the possible approaches to this issue. Section III sums up the results and discuss their significance to economic fields. Section IV covers the relation between economic policy and persistence of innovations. Finally, the last section summarizes some important implications resulting from our results.

II. Methodology:

The issue of persistence of innovations can be addressed using two methodologies. The first one is the parametric approach, where impulse response functions are calculated from ARIMA models.

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1 See also Chan, Hayya and Ord (1977), and Nelson and Kang (1984).

2 In fact these two practices are equivalent.

3 There are however several approaches. For instance, see Harvey (1984), Watson (1986) and Clark (1987) for structural models. For an analysis based on Markovian Processes see Hamilton (1989).
previously estimated [Campbell and Mankiw (1987)]. Let $Y_t$ be the logarithm of GDP. Assuming that its first difference is stationary of second order, and modelling it as an ARIMA we have:

$$\phi(B)(1-B)Y_t = \theta(B)\varepsilon_t$$  \hspace{2cm} (1)

where $B$ is the Backward Shift Operator and $\varepsilon_t$ is white noise. From (1) we get:

$$Y_t = \psi(B)\varepsilon_t$$  \hspace{2cm} (2)

where $\psi(B) = (1-B)^{-1}[\phi(B)]^{-1}\theta(B)$. Now we have that

$$\psi_i = \sum_{j=0}^{i} \psi_j$$  \hspace{2cm} (3)

The limit of $\psi_i$ is the sum of coefficients of an infinite moving average representation for the level of $Y_t$, denoted by $A(1)$. Then, for large $i$ $\psi_i$ is a measure of persistence, since it is nothing more than the accumulation of the effects of an innovation in $t$.

This parametric approach, however, has some limitations. One of them is related to model specification. Like any parametric approach, there is no consensus in this field at all about what is the best method of model selection. Another serious restriction is the fact that two different models that seem to describe data equally well can give widely differing results for the long-run persistence of innovations.$^4$ Furthermore, this type of analysis often leads to an overestimation of the long-run persistence.$^5$

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$^4$See e.g., Watson (1986).

The second approach is to use a nonparametric measure, such as the one developed in Cochrane (1988). He considers two different processes, one with deterministic trend (eq. 4), and the other a random walk with drift $\mu$ (eq. 5):

$$Y_t = bt + \sum_{j=0}^{\infty} \lambda_j \epsilon_{t-j}$$

$$Y_t = \mu + Y_{t-1} + \epsilon_t$$

where $\epsilon_t$ is white noise. Taking the variance of $Y_t$ in both cases, and dividing it by $k$ times the variance of first difference we get:

$$V_k = \frac{2}{k} \frac{\sigma_k^2}{\sigma_1^2}$$

for the deterministic case, and:

$$V_k = \frac{\text{Var} (\epsilon_t)}{\text{Var} (\Delta Y_t)}$$

for the random walk. It is then possible to see that:

$$\lim_{k \to \infty} V_k = \begin{cases} 
0 & \text{in the deterministic case} \\
1 & \text{in the random walk case} 
\end{cases}$$

6 In fact there is no consensus in the literature about what is the most appropriate measure of long-run persistence. See e.g., Stock and Watson (1988).
Thus it is possible to use Cochrane's nonparametric measure to quantify the persistence of an innovation in log GDP. It can take any value ranging from 0 (the deterministic case) up to more than one.\(^7\) That is:

\[
V_k = \frac{\text{Var} (Y_t - Y_{t-k})}{k \text{Var} (Y_t - Y_{t-1})}
\]

(8)

is, for large \(k\),\(^8\) a measure of how persistent the innovations are. An estimator for \(V\) is given by:

\[
\hat{V}_k = 1 + 2 \sum_{1}^{k-1} \frac{k-j}{k} \hat{\rho}_j
\]

(9)

where \(\hat{\rho}_j\) is the \(j\)'th sample autocorrelation coefficient from the first difference of the series.

One clear advantage of this analysis is that one has not to choose among competing models. Furthermore, it does not depend on the correlation between innovations in the secular component and in the cyclical component of GDP.\(^9\) However, although this nonparametric measure does not encounter problems like model specification, it has its limitations as well. There is an explicit relationship between Cochrane's measure and Campbell-Mankiw's impulse response function.\(^10\) Moreover, one has to be especially

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\(^7\) Of course it is 1 in the random walk case.

\(^8\) A bias correction of \(n/(n-k+1)\) is usually applied, since there is a downward bias for large values of \(k\).


\(^10\) It is easily shown that \(A(1) = \left[V/(1-R^2)\right]^{1/2}\), where \(R^2\) is the fraction of variance that can be predicted from past information, i.e., \(R^2 = 1 - (\sigma^2/\sigma^2_e)\). \(R^2\) can be approximated by the first order
careful in the case where the data is generated by a more complex process, that is, when we have an ARIMA model with many parameters. In this particular situation it is more difficult to distinguish between the permanent incorporation of the shock and a slow return to the trend line, the so-called long memory case.\textsuperscript{11}

We shall use this second approach in answering the question posed in the introduction. The empirical results are summarized in the next section.

III. Empirical Evidence of Shock Dominance:

The first step in our investigation\textsuperscript{12} is to carry out the Dickey-Fuller test\textsuperscript{13} for the presence of unit roots. The following results were obtained:

\[
\hat{Y}_t = -6.0945 + 0.9463 Y_{t-1} + 0.0362 \Delta Y_{t-1} + 0.0033 t \tag{10}
\]

\[
(2.9527) \quad (0.0290) \quad (0.1084) \quad (0.0016)
\]

\[
R^2 = 99.89\% \quad Q(27) = 10.56
\]

where $Y_t$ is the logarithm of the index of real GDP, $t$ is the year sample autocorrelation. Notice that the square root of Cochrane’s measure can be seen as a lower bound for Campbell-Mankiw’s measure. Nevertheless, one should note that this result holds for $k$ tending to infinity. The truncation can be a serious problem here.

\textsuperscript{11}See Diebold and Rudebusch (1989).

\textsuperscript{12}The sample consists of the index of Brazilian real GDP from 1900 to 1985 (1939=100). The series was built in the following way. For the period 1900-1947 we used the estimates given in Haddad (1977). Then we applied the annual growth rate of the real GDP given in Instituto Brasileiro de Geografia e Estatistica (1987) starting with the value of 1947.

\textsuperscript{13}For this test we used the table given in Fuller (1976) p.373. For more details, see Dickey and Fuller (1979).
and the standard deviations for the parameters are in parentheses. Based on the results above we have $\hat{\tau} = -1.85$ and we cannot reject the null hypothesis of a stochastic trend.

As a second step we calculate Cochrane's nonparametric measure and the corresponding Campbell-Mankiw's impulse response function (see note 10). Table 1 presents the results, and $c$ indicates that a bias correction was applied (see note 10).

The results shown above indicate that an innovation of one percent in the current product is more than proportionately incorporated in the long-run. In this case, we call this situation shock dominance.

One can then ask the following question: What are the causes of the persistence of innovations? There is no consensus about these causes, and yet we believe three causes are especially important. First, shocks of technology have no self tendency to dissipate. In this sense, this kind of innovation is fully persistent. Secondly, consumption is a significant part of GDP and it exhibits a highly stochastic behavior. As shown by Hall (1978), it is an implication of Permanent Income Hypothesis that consumption evolves as a random walk with drift. In this sense, an innovation of one percent in this variable is incorporated by the same magnitude in the long-run. Thus, GDP will tend to show, to some extent, an incorporation of innovations as well. Finally, we have the role of investment on the permanence of shocks. Investment links the present to the future, since it is nothing more than future production. Given this, if a shock affects investment decisions today, it will affect future levels of output. In particular, a shock has significant effects on investment when it damages the credibility and/or increases the uncertainty.

14 Note that the regression is clean of serial correlation.

15 Flavin (1981) carried out an equivalent test and got different results. However, as shown by Mankiw and Shapiro (1985) and Nelson (1987) this difference can be explained in statistical grounds, once Flavin used detrended data, whereas Hall used data in levels.

16 See Hall (1986).
TABLE 1: NONPARAMETRIC MEASURES FOR PERSISTENCE OF INNOVATIONS IN THE BRAZILIAN REAL GDP (1900/1985)

<table>
<thead>
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IV. Persistence of Innovations and Economic Policy:

It is well known that government can affect the current output through its economic policy.\(^{17}\) Therefore, a natural question to be asked is: Can economic policy alter the persistence of an innovation? This is a very important question and there is not a conclusive answer. One situation where the answer is yes, is when a shock increases the uncertainty in the economy and the economic policy is successful in reducing this uncertainty. If this policy does not lead to negative effects on future output, it will very likely reduce the permanence of that shock. In this section we try to verify this claim using the Brazilian experience after the first international shock in oil prices.

Brazil has shown a historical tendency to avoid adjustments when faced with adverse conditions. Since 1930 several examples can be given where the necessary adjustment was avoided. For instance, the Brazilian Government bought a considerable part of internal production of coffee to help farmers during the big crisis of the 30’s. More recently, Brazil refused to adjust after the two international shocks in oil prices. After 1979 and consequently after the second shock in oil prices, Cardoso and Dornbusch (1988) affirm that Brazil adopted a *muddling through* policy, once more avoiding the necessary adjustments.

However, the Brazilian response to the first oil shock was the most meaningful one. According to Baer (1989, pp.96-97):

At the time, Brazil had two options in reacting to the oil shock. It could either substantially reduce growth in order to diminish its nonoil import bill, or it could opt for continued relatively high growth rates. The later implied a substantial decline in country’s foreign reserves and/or a substantial increase in its foreign debt. Brazil opted for the second alternative.

\(^{17}\) Note that we are not saying that government can stabilize the economy.
Still, according to Baer, the goals of the Second National Development Plan (II PND), strongly based on massive government investment and introduced at that time, were to extend import substitution of many important industrial inputs and capital goods and expand the economic infrastructure. In a broader context, this policy aimed to act as a countercyclical maneuver and to change the structure of the economy.

Nevertheless, it made the country run up a huge external debt, which rose from US$ 12.3 billion in 1973 to US$ 43.5 billion in 1978, before the increase of the world interest rates. Moreover, the annual inflation rate increased from 16.2% in 1973 to 40.5% in 1978. In this sense, Marques (1989) claimed that a passive monetary policy from 1974 to 1979 transferred, to a large extent, the effects of the first shock from output to prices through an acceleration of the inflation rate.

Accordingly, Tombini and Newbold (forthcoming) use an analysis of interventions to evaluate the short-run effects of three shocks in Brazilian GDP, namely: the political upheavals of the early 1960's and the two oil shocks. Their results show that "even by 1977, trend gross domestic product had fallen less than 10% of what it would be in the absence of the first oil shock." These results lead them to conclude that "the performance of the Brazilian economy in reaction to the 1973 shock was quite satisfactory." However, their results only show the short-run effects in GDP and "takes no account of how this performance was made possible."

Thus, the effect of this policy on the persistence of the shock was dubious. On the one hand, it reduced the uncertainty in the economy and reduced the impact of the oil shock on the investment. On the other hand, it accelerated inflation and increased the external indebtedness.

It is possible to see that the policy was successful in reducing the uncertainty by looking at the absolute values of the sample first order autocorrelation from the first difference of the logarithm of the real GDP in different periods. Table 2 presents these values.
The numbers above represent the predictable fraction of the growth rate of the real GDP, since we are dealing with difference of logs. For,

\[ \Delta \log(x_t) = \log(x_t) - \log(x_{t-1}) = \log\left(\frac{x_t}{x_{t-1}}\right) = \left(\frac{x_t}{x_{t-1}}\right)^{-1} \]

This fraction increased substantially in 1974, indicating that the policy reduced the uncertainty created by the shock in oil prices. This fraction declines after that, but it stabilizes at the previous level until 1980. In 1981 it decreases due to the Brazilian response to the second international shock in oil prices and the world interest rates shock.

Can anything be said about the net effect of the Brazilian policy on the persistence of the first oil shock? In order to try to give an answer for this question we reran Cochrane’s measure and calculated the corresponding impulse response function for the period 1900 to 1973. Table 3 presents the results. Figures 1 and 2 show the measures of persistence for both periods.

From this it is possible to see that the degree of persistence of an innovation in the Brazilian GDP at the time of the first international shock in oil prices was very high (more than twice
the magnitude of the original shock if we consider Cochrane's measure or almost twice if we consider Campbell-Mankiw's impulse response function). This degree of persistence is higher than the one obtained for the whole period (table 1). This indicates a structural difference between the periods.

We must point out that Priestley's standard error of Cochrane's measure is too high. For the whole period we have a standard error of 1.16, and for the period 1900-1973 it is 1.96. In this sense, the present results should be viewed with caution. However, this is an asymptotic standard error that relies on a normal limiting distribution, and Cogley (1990) shows that this is not a good approximation. In particular, he shows that the lower tail of the normal distribution is too fat, and thus "the lower tail of a normal confidence interval will include values of the variance ratio that the empirical distribution reveals to be unusually small." [Cogley (1990, p.505)] In order to overcome this problem of wide confidence intervals we would need either a quarterly or longer series, what is not available for the Brazilian case. Addressing this point, Campbell and Mankiw (1987, p.873) say that "the usefulness of this standard error in samples of typical size (...) is unclear."

Although we must be careful in analyzing the results given the problem mentioned above, the lower degree of persistence for the sub-period seems to indicate that Brazilian economic policy was really capable of moving some of the effects of the first oil shock to other variables, as claimed by Marques (1989). In this sense, it is interesting to note that both measures (Campbell-Mankiw and Cochrane) show the same behavior. In both cases, the effects of the shock is quite similar for the whole period and the sub-period up to (approximately) ten years after the innovation. From this point on, the measures show a divergence, the long-run effects of a shock being lower for the whole period.

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18 Priestley's standard error is given by: \( SE(V_c^k) = (4k/3n)^{0.5} \hat{V}_c^k \), where \( n \) is the number of observations.

19 Diebold and Rudebusch (1989) face a similar problem.
TABLE 3: NONPARAMETRIC MEASURES FOR PERSISTENCE OF INNOVATIONS IN THE BRAZILIAN REAL GDP (1900/1973)

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Figure 1: Cochrane's Measure: 1900-85 and 1900-73

Figure 2: Campbell-Mankiw's Measure: 1900-85 and 1900-73
Therefore, the Brazilian experience is a first indication that there is a relationship between economic policy and shock incorporation. We have tried to investigate the effect of a policy under very special conditions, that is, in the situation where the shock seems to affect mainly the investment and where the government reaches its target of reducing the uncertainty and minimizing the effects on total investment, without generating problems capable of offsetting the achievement of those goals.

IV. Implications and Conclusions:

We can highlight several of the important implications of the results presented here. First, one has to be careful in measuring cycles, since the traditional methods tend to overestimate this component. Secondly, innovations in the Brazilian GDP are highly permanent. An innovation is incorporated by more than its original magnitude. Finally, we investigated the influence of economic policy on the persistence of innovations using the Brazilian experience after the first international shock in oil prices. Our results show that the Government was capable of reducing the persistence of that shock in the GDP. At that time the economic policy reduced uncertainty and the effects of the shock on investment. This fact leads us to conclude that under special circumstances there is a relationship between economic policy and persistence of innovations. Therefore, on some occasions, stabilization policies do have long-run effects.
References:


