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Working Paper

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Texto para discussão, No. 349

Provided in Cooperation with:
Departamento de Economia, Pontifícia Universidade Católica do Rio de Janeiro

DEPARTAMENTO DE ECONOMIA

PUC-RIO

TEXTO PARA DISCUSSÃO
N.º 349

UNIT ROOTS IN THE PRESENCE OF ABRUPT GOVERNMENTAL INTERVENTIONS WITH AN APPLICATION TO BRAZILIAN DATA

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DEZEMBRO 1995

Unit Roots in the Presence of Abrupt Governmental Interventions with an Application to Brazilian Data*

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First Draft: October 1995
This version: December 1995

*We thank the financial support from the Programme d'Analyses et de Recherches Économiques Appliquées au Développement International (PARADI) financed by l'Agence Canadienne de Développement International (ACDI). The first author also aknowledges financial support from the Social Sciences and Humanities Research Council of Canada (SSHRC), the Natural Sciences and Engineering Council of Canada (NSERC) and the Fonds de la Formation de Chercheurs et l'Aide à la Recherche du Québec (FCAR). Address for correspondance: Pierre Perron, CRDE, Université de Montréal, C.P. 6128, Succ. Centre-Ville, Montréal, Québec, Canada, H3C-3J7. E-mail: perronp@plgcn.umontreal.ca.

Abstract

This paper considers econometric issues related to time series data that have been subject to abrupt governmental interventions. The motivating example for this study is the Brazilian monthly inflation and interest rate series (1974:1-1996:4) which we use throughout for illustration. These series have been heavily influenced by the effect of so-called shock plans implemented by various governments starting in the mid 80's. The plans act as "inliers" in the sense that the series are temporarily brought down to low levels before returning to their previous trend path. We analyze the effects on standard unit root tests and measures of persistence caused by the presence of these "inliers". We show a substantial bias in favor of concluding that the series are stationary and that shocks have temporary effects. We then construct appropriately corrected statistics which take into account the presence of the plans. These show, unlike the standard tests, that the stochastic behavior of inflation and interest rate was indeed explosive over this period. Simulation results are presented to support the adequacy of our corrected statistics.

Keywords: Structural Change, Inliers, Shock Plans, Measures of Persistence, Explosive Process, Nonstationarity.

1 Introduction.

Nonstationarity in economic data can take various forms; for example, the presence of an autoregressive unit root in the univariate representation of a series, the presence of cointegration in a system of variables, the presence of structural changes in a functional relation amongst a set of variables, etc. In this paper, we discuss an alternative form of nonstationarity related to the effects of abrupt governmental interventions also referred to as "shock plans".

Our analysis is directly motivated by the time series properties of the Brazilian inflation rate (the nominal interest rate is also of relevance given its similar behavior). This series is characterized by important increases starting in the early 80's, turning into hyperinflation in the mid 80's. Yet, this period of very high inflation has been marked by a few (5 that are important until the early 90's) "shock plans" which have brought inflation to a low level for a short period of time. Intuition suggests that, in this highly volatile period with an ever-increasing trend path for inflation, standard statistical measures related to the issue of nonstationarity and the persistence of shocks would show the series to be highly persistent and nonstationary. Yet, exactly the opposite occurs. Standard unit root tests suggest that inflation was stationary in that period and that shocks affected its level in a temporary manner. Indeed, standard measures suggest that inflation was "more stationary" and less persistent in this hyperinflation period than in the 70's when inflation was moderate.

The issue we want to analyze is first, whether these results are the artifact of the presence of the temporary changes created by the shock plans. To get some intuition on this issue, we can view these shock plans as creating "inliers" whose magnitude is related to the current level of the series. Hence, if the series truly has a stochastic trend (i.e. a unit root) or even an explosive path, the magnitude of these "inliers" are, themselves, nonstationary random variables which have a tendency to increase as inflation increases. Since these shock plans have failed, the series exhibits a tendency to return to its old (nonstationary) trend path after each episode. This is basically what contaminates the standard statistical measures, since the failures of the shock plans create a kind of spurious mean-reverting aspect to the series.

This argument is fundamentally the flip-side of the argument exposed in Perron (1989, 1990) where permanent changes in the trend function of a series with a stationary noise bias standard unit root tests and persistence measures towards accepting the unit root hypothesis and concluding that shocks have persistent effects. Here, temporary, but large, changes bias these measures in the opposite direction.

The problem is somewhat related to the analysis of Frances and Haldrup (1994) who considered the effect of additive outliers. They showed how unit root tests have liberal size distortions when a series with a unit root is contaminated by additive outliers (see also Vogelsang (1994)). The issue is, however, qualitatively different in two aspects. First, the occasional events occur for more than a single period, lasting usually several months. Hence, we cannot properly view them as outliers. Secondly, and more importantly, the magnitude of the "inliers" or shock plans is directly related to the actual level of the series and is, hence, a nonstationary random variable.

The aim of the paper is first to provide a detailed analysis of the statistical effects of such "inliers" on standard statistical tools such as unit root tests and measures of persistence. The second goal is to provide modifications to these standard tests that directly take into account the presence of the shock plans. As we shall see, the answers obtained are dramatically different. Note finally that, while the methodology developed in this paper is directly motivated by and applied to the Brazilian inflation (and nominal interest) rate series, the tools developed will be of direct application to a wide variety of cases where a series is affected by temporary but important events; for example, wars, strikes, etc.

The structure of the paper is as follows. Section 2 describes in detail the data used and Section 3 briefly discusses the historical settings surrounding the shock plans implemented by the various Brazilian governments. The results obtained from the application of standard unit root tests and measures of persistence are presented in Section 4. The bias of the unit root tests in the presence of occasional shock plans is analyzed, via simulations, in Section 5. Our results show that standard unit root tests are severely biased by the shock plans towards a rejection of the unit root hypothesis in favor of stationary fluctuations around a stable linear trend function. Accordingly, Section 6 considers modified versions of the tests that explicitly take into account the presence of the shock plans. Some simulations show that these modifications yield tests with correct sizes and the empirical results show a very different picture. Indeed, we no longer reject the unit root hypothesis in favor of stationary alternatives but we now reject in favor of explosive alternatives as appears intuitively plausible in a period of hyperinflation.

2 Description of the Data.

The series used in this paper are the monthly Brazilian inflation and nominal interest rates for the period 1974:1 to 1994:6. Note that the choice of 1994:6 as the end of the sample is to avoid incorporating the Real Plan which is still in effect. The nominal interest rate is defined as the monthly compound overnight rate. It is the rate charged by the central bank in its daily sales and purchases of reserves (and is, hence, basically the equivalent of the FED funds rate in the United States).

For the inflation rate, we use what is called the "official inflation index". This is actually a splice of several indices that was used by the government as the official index to all mandatory indexation schemes (for taxes, wages, etc.). This index was also widely used by the financial markets and the central bank used it to calibrate the real interest rate. We applied two modifications to this "official index". First, since the price index is computed from an average of the daily prices from the beginning to the end of the month, the measured monthly inflation reflects price changes from the middle of the previous month to the middle of the current month. To obtain a better approximation of price changes from beginning to end of month, we used a geometric mean with equal weights of inflation over periods t and $t+1$. Secondly, given the sudden and important changes in inflation caused by the shock plans, the usual continuity assumption that justifies the use of monthly averages breaks down. In order to mitigate the problems caused by averaging in this context, we used, for the months immediately following the plans, special price vectors computed by the government at the moment of each plan.

Graphs of the inflation and interest rates series are presented in Figures 1 and 2, respectively. As is evident from a glance at these graphs, both series are characterized in the 80's by several sudden drops that are important in magnitude. These drops are the outcome of the various shock plans instituted by the governments in an attempt to stop the process of high and increasing inflation.

Table I presents a summary of the various plans along with the dates we retained to define them and the magnitude of the decrease in inflation. The starting date of a plan was decided as the first month when over this month (and possibly the next one due to overlap) the decrease in inflation was at least 40% compared to its level in the preceding month. Choosing the ending date of a plan is somewhat more difficult. Our choice was guided both by historical records and by the use of dummy variables to create a real interest rate series with as few outliers as possible. It is important to note, however, that the results presented in this paper are not sensitive to minor variations in the choice of the ending dates for the plans.

Given the importance of the shock plans for the time series behavior of the inflation and interest rate series, we start with a brief historical overview.

3 A Brief History of the Shock Plans.

After a short period of economic reforms in the mid-sixties, the Brazilian economy grew fast and sharply for almost a decade throughout the seventies. The Brazilian Gross Domestic Product growth rate was about 7.5%, on average. The yearly inflation rate was stable around 20% until the oil shock in 1973. The strategy adopted for economic development was a success because of a profitable combination of external financing and a strong government support to private and public investments. This situation changed with the oil shocks in 1973 and in 1979 which were followed by an increase in the cost of external financing after the abrupt rise in interest rate at the beginning of the eighties.

In contrast, high inflation rates and diminishing GDP growth rates were the norm starting in the eighties. The first attempt to stabilize the economy was carried by a so-called orthodox economic team in 1982. The internal interest rate was raised above the international level; a plan for deficit reduction was proposed and a wage desindexation policy was adopted in order to restrict the internal aggregate demand. The external restriction imposed by the interest payments constraint and the lack of an international financial market that would provide financial aid to Brazil, or any other country in Latin America, inverted Brazil's former position in international trade. From 1984 on, the Brazilian trade balance was positive enough to meet international commitments. Despite the soundness of those economic decisions, the inflation rates did not fall below two digits a month. It was kept stable around 150% per year. On the other hand, Brazilian GDP decreased by 2.0%, on average, in two years and it barely grew by 1.0%, on average, until the middle of the decade. Hence, this economic period was labelled as one of stagflation.

With the end of the dictatorship and the election of a new president at the beginning of 1985, the expectation was that a democracy would succeed in setting up a new economic order. However, high inflation rates and a lack of economic stability still persisted. After a long and deep recession, with high costs to the former government, the New Republic rulers decided to manage the situation without imposing more social costs. Hence, this time brought renewed discussions about the inflation rate and alternative proposals to manage it. The inertial inflation approach appeared as an alternative answer to the problem. Though the proponents of the inertial inflation approach agreed on a more orthodox diagnostic, no agreement was reached for the fight against inflation. For the inercialists, a traditional orthodox plan to stabilize the economy would imply high social costs for implementation. This alternative would require, probably, many years to bring the inflation rate down to a single digit figure and there was reluctance to wait and accept more losses.

A Monetary Reform based on a general desindexation and a change of currency was the core of the Cruzado Plan in 1986, Brazil's first heterodox attempt to stabilize the economy. A price freezing was also deemed necessary to avoid extra income gain or losses during the stabilization plan. Hence, the Cruzado Plan was also followed by a general price freezing. With hindsight, it is possible to criticize the Cruzado Plan by the way they established the initial level of some key economic variables. The interest rate was set below the international level and most of the times negative in real terms. Then a consumption bubble and price pressures from the demand side imposed pressures to put aside the Plan against inflation. In July 1986, many commodities in the supermarket disappeared and goods such as gas, gasoline, etc. were subject to rationing. However, election and political pressures delayed changes until November. At that time, the government and its economic team could not keep the stabilization process under control, so the inflation rate again reached a two digits figure per month (at about 14.5% in January 1987). The year following the Cruzado Plan showed high inflation rates, uncertainty and disagreement about the right economic policy to follow. At the same time, industrial production and investments started declining again.

By June, the inflation rates were out of control and the relative prices were disorganized. After a substitution of the Minister of Finance in April, a new stabilization plan was tried: the macroeconomic Consistency Plan, also called Bresser Plan. Even though this was an attempt to correct the wrong path taken before it still insisted on freezing prices again. As with the Cruzado Plan, the Bresser Plan was unable to solve the problem of the public deficit. A lack of control on this deficit and additional political pressures hampered any attempt to cut spending and the Finance Minister could do no more again then watch further increases in inflation.

After another Finance Minister substitution in January 1988, Brazil witnessed the highest inflation rates in its history another stabilization, called Summer Plan, was tried a year later. It was an attempt analogous to that of Argentina. This Plan was based upon a tight Monetary Policy; the interest rates were raised far above their historical levels and the government took the opportunity to change the feature of its internal debt (the government changed LFT (Treasury Financial Notes) by BBC (Central Bank Notes) and other longer maturity debt instruments). Once more, the fiscal situation was not solved and the inflation rate turned up again. By the end of Mr. Sarney's term, it had reached as high as 85% a month. The country was close to a hyperinflation and economic chaos.

This path persisted until March 1990, when a newly elected president took office, Mr. Fernando Collor de Melo. His first economic decision was a Monetary Reform that sequestered about 75% of all financial assets. They were converted into long-run deposits under the responsibility of the Brazilian Central Bank. The money supply fell down sharply and, accordingly, so did the inflation rate, and the economic activity registered a strong contraction. This economic plan was so efficient in the short run that, after two months, the inflation rate appeared stable at a low level. The internal total debt decreased and the interest payments diminished which gave a short breath to the Treasury's financial operation. However, as the total debt problem was not solved and the government did not manage its spending, the inflation went back to 20% a month in December 1990.

At the beginning of 1991, the economic team desperately tried again to stabilize the economy through a mixture of price freezing and public spending cuts. That was Collor II Plan which lasted less than four months. Due to a severe recession, the inflation rates stabilized around 20% a month for the rest of President Collor's term. Political problems, corruption and the increase of uncertainty are ingredients of a more general crisis that ended with the impeachment of President Collor in December 1992. He was replaced by the vice-president, Mr. Itamar Franco, who inherited an inflation rate close to 30% a month. This inflationary feature went on until July 1994 (approximately 50% a month), when a new and, up to now, successful plan was introduced, the Real Plan.

4 Empirical Results with Standard Unit Root Tests.

In this section, we discuss empirical results obtained with the application of some standard unit root tests. By that we mean that the tests do not take into account the presence of the shock plans and their effects on the level of the series. We start with a description of the statistics as well as a measure of persistence. The empirical results are then discussed highlighting the potential problems of this standard approach.

4.1 The test statistics.

For our analysis, we use three tests for the presence of an autoregressive unit root. The first two are by now standard tools in the analysis of univariate data, namely the Augmented Dickey-Fuller (1979) test (labelled ADF) and the Phillips-Perron (1988) test based on the normalized bias in a first-order autoregression (labelled Z_α). We also consider a new test suggested by Stock (1990) and further analyzed by Perron and Ng (1996) which is a modification of the Phillips-Perron test that is less subject to size distortions in the presence of serial correlation in the first-differences of the data (this test is labelled MZ_α). Finally, we consider a measure of the persistence of shocks based on an autoregressive spectral density estimator at frequency zero.

The class of processes considered can be described as follows. We denote the relevant data series by y_t (the inflation rate or the interest rate in our case) and write:

$$\begin{aligned} y_t &= \mu + \beta t + z_t, \\ A(L)z_t &= B(L)e_t, \end{aligned} \tag{1}$$

where $A(L) = 1 - a_1L - a_2L^2 - ... - a_pL^p$ is a p^{th} order autoregressive polynomial in the lag operator L (defined such that $Lx_t = x_{t-1}$). Similarly $B(L)$ is a q^{th} order moving-average polynomial defined by $B(L) = 1 + b_1L + b_2L^2 + ... + b_qL^q$. The errors $\{e_t\}$ are assumed to be martingale differences (e.g., uncorrelated but not necessarily homoskedastic). The system (1) simply describes a process that is the sum of a deterministic time trend (a first-order polynomial in time) and a noise function modeled as an $ARMA$ process. Of course, more general processes are possible, but for simplification of exposition we consider this leading case of interest.

The null hypothesis is that one root of the autoregressive polynomial is unity, i.e. we have the factorization $A(L) = (1 - L)A^*(L)$ with all the roots of $A^*(L)$ outside the unit circle. Note that this implies that the sum of the autoregressive coefficients is unity. The usual alternative hypothesis is that the sum of the autoregressive coefficients is less than one (in which case z_t is stationary) but given the nature of the series analyzed here we also consider the alternative hypothesis that this sum is greater than one, i.e. z_t is an explosive process.

The ADF tests of Dickey and Fuller (1979) (also extended by Said and Dickey (1984) to the case of data having an $ARMA$ structure) is based on the idea that a stationary and invertible $ARMA$ process can be approximated by an autoregression.

Hence, the relevant regression estimated by OLS is:

$$y_t = \eta + \gamma t + \alpha y_{t-1} + \sum_{j=1}^{k} c_j \Delta y_{t-j} + v_t. \tag{2}$$

Here, the parameterization (2) is such that α is the sum of the autoregressive coefficients. Hence, the null hypothesis can be tested using the t-statistic constructed for $\alpha = 1$. An issue of empirical importance is the choice of the order of the autoregression k. Following Campbell and Perron (1991) and Ng and Perron (1995), we use a data-dependent method based on a general to specific recursive procedure. Starting from some maximal order $k\max$, the method tests if the last included lag is significant and if not the order of the autoregression is decreased by one and the coefficient of the last lag is again examined. This is repeated until a rejection occurs or the lower bound 0 is reached. We present results with $k\max = 5$, but also report sensitivity analyses with respect to other choices of the upper bound.

The unit root test of Phillips and Perron (1988) is based on a nonparametric correction of the autoregressive estimate, $\hat{\alpha}$ in the following first-order autoregression:

$$y_t = \eta + \gamma t + \alpha y_{t-1} + u_t. \tag{3}$$

Denote the estimated residuals by $\hat{u}_t$ and its sample variance by $s_u^2 = T^{-1}\sum_{t=1}^{T} \hat{u}_t^2$. Also let $\tilde{y}_{t-1}$ be the residuals from a projection of y_{t-1} on a constant and a time trend, the test is defined as:

$$Z_\alpha = T(\hat{\alpha} - 1) - (s^2 - s_u^2)/(2T^{-2}\sum_{t=1}^{T} \tilde{y}_{t-1}^2), \tag{4}$$

where s^2 is a consistent estimate of the spectral density function at frequency zero of Δz_t under the null hypothesis of a unit root, denoted $h_{\Delta z}(0)$. The conventional estimator of this quantity is based on a kernel or window method that constructs a weighted sum of the empirical autocovariances of the estimated residuals $\hat{u}_t$ (see, e.g. Andrews (1991)). For example, using the Bartlett weights as suggested by Phillips and Perron (1988) and Newey and West (1987). However, Perron and Ng (1995) found this estimator to be inferior to an autoregressive spectral density estimator based on the first-differences of the data. In particular, it allows the transformed test MZ_α, defined below, to have good size and power properties in the presence of strong serial correlation. Hence, we shall construct our results using the latter. This estimator is defined by:

$$s^2 = s_{ek}^2/(1 - \hat{b}(1))^2, \tag{5}$$

with $s_{ek}^2 = T^{-1}\sum_{t=1}^{T}\hat{e}_{tk}^2$, $\hat{b}(1) = \sum_{j=1}^{k}\hat{b}_j$ where $\hat{b}_j$ and $\{\hat{e}_{tk}\}$ are obtained from a k^{th} order augmented autoregression in Δy_t:

$$\Delta y_t = c + b_0 y_{t-1} + \sum_{j=1}^{k} b_j \Delta y_{t-j} + e_{tk}. \tag{6}$$

The consistency of s^2 for $h_{\Delta z}(0)$ under the null hypothesis of a unit root follows from the results of Said and Dickey (1984) and Berk (1974). In empirical applications, a feature of importance is again the choice of the truncation lag. This issue is the subject of ongoing research by one of the authors. From preliminary simulation results, it appears that the general to specific recursive procedure that works well for the ADF test does not perform as well here in providing tests with proper finite sample sizes. Instead, simulation results discussed in Perron and Ng (1995) show that a data-dependent method that selects, on average, a more parsimonious structure performs better. In particular, the use of the BIC criterion permits obtaining estimates of the spectral density function at the origin that have smallest mean-squared error under the null hypothesis of a unit root (unless the noise component is heavily negatively serially correlated). Accordingly, in the empirical applications we select the order of the autoregression (6) as that value of k which minimizes the BIC criterion. An important point to note is that s^2 is bounded above by zero even under the alternative of a stationary noise function z_t. This latter fact is important since it ensures the consistency of the modified statistic which we now describe.

Stock (1990) proposed a class of statistics which exploits the feature that a series converges with different rates of normalization under the null and alternative hypotheses. We consider one such test, referred to as MZ_α, defined by

$$MZ_\alpha = (T^{-1}\tilde{y}_T^2 - s^2)/(2T^{-2}\sum_{t=1}^{T}\tilde{y}_{t-1}^2), \tag{7}$$

where again $\tilde{y}_t$ are the residuals from a projection of y_t on a constant and a trend and s^2 is the autoregressive spectral density estimator defined by (5) and (6). This statistic can be written as

$$MZ_\alpha = Z_\alpha + (T/2)(\hat{\alpha} - 1)^2. \tag{8}$$

For this reason, we can view MZ_α as a modified Phillips-Perron test. The modification factor $(T/2)(\hat{\alpha}-1)^2$ is asymptotically negligible but plays a very important role in finite samples when the series exhibit strong serial correlation. These issues are examined in detail in Perron and Ng (1996) where, in particular, it is demonstrated theoretically and via simulations that this test has superior size and power properties for a wide range of data-generating processes.

A topic that has received substantial attention recently is the measure of the persistence of shocks on the level of a given series. Here the concept of persistence relates to the long term effect of a shock e_t in (1) on the level of y_t (see, e.g. Cochrane (1988) and Campbell and Mankiw (1987)). All the measures of persistence proposed are directly related to the normalized spectral density function at frequency zero of the first-differences of a series, $f_{\Delta y}(0) = h_{\Delta y}(0)/\sigma^2_{\Delta y}$ where $\sigma^2_{\Delta y}$ is the variance of the first differences of the series y_t. For example, if the series is trend-stationary, $f_{\Delta y}(0)$ is 0 and the series exhibits no persistence. For a random walk, it is one and shocks have a one for one effect on the long term level of the series. When $0 < f_{\Delta y}(0) < 1$, shocks have a permanent effect but their influence is attenuated over time. If $f_{\Delta y}(0) > 1$, their effect is exacerbated over time. Hence, an estimate of $f_{\Delta y}(0)$ can provide valuable information on the characteristics of a time series of data. Here, we consider an estimate defined by $\hat{f}_{\Delta y}(0) = \hat{h}_{\Delta y}(0)/\hat{\sigma}^2_{\Delta y}$ where $\hat{\sigma}^2_{\Delta y} = T^{-1}\sum_{t=1}^{T}(\Delta y_t - \overline{\Delta y})^2$, the sample variance of Δy_t and where $\hat{h}_{\Delta y}(0)$ is an autoregressive spectral density estimate at frequency 0 defined by

$$\hat{h}_{\Delta y}(0) = s^2_{ek}/(1 - \hat{d}(1))^2, \tag{9}$$

with $s^2_{ek} = T^{-1}\sum_{t=1}^{T}\hat{e}^2_{tk}$, $\hat{d}(1) = \sum_{j=1}^{k}\hat{d}_j$ where $\hat{d}_j$ and $\{\hat{e}_{tk}\}$ are obtained from the following k^{th} order augmented autoregression in Δy_t:

$$\Delta y_t = c + \sum_{j=1}^{k} d_j \Delta y_{t-j} + e_{tk}. \tag{10}$$

Note that (10) differs from (6) in that the lagged level y_{t-1} is not included. This ensures consistency under both the null and stationary alternative hypotheses and a more efficient estimator under the null hypothesis of a unit root. The truncation lag is again selected using the BIC criterion.

4.2 Empirical results.

We applied the test discussed above to the Brazilian monthly inflation and interest rates series for the period 1974:1-1994:6. The results are presented in Table II for inflation and Table III for the interest rate. Since the qualitative results are very similar for the two series, we concentrate on those related to inflation. We then return to briefly characterize some differences found for the interest rate.

The strategy adopted was to conduct the tests for the full sample and various subsamples with and without shock plans. Consider first the results for the full sample. All three unit root tests concur for an overwhelming rejection of the null hypothesis of a unit root in favor of stationary fluctuations. All statistics are significant at the 1% level (the critical values, from Fuller (1976), are -21.8 for Z_α and MZ_α and -3.41 for ADF). Furthermore, the results are quite robust to alternative choices of some auxiliary parameters, for example choosing $k\max = 10$ in constructing the ADF. This robustness remains valid for the other subsamples considered so we shall not repeat it further and we simply discuss the main results using $k\max = 5$ for the ADF. We note, for further comparisons, that the measure of persistence given by the estimate of the spectral density function at the origin of the first-differences of the data is .91, a value substantially above 0 which contrasts with the unit root tests.

Consider now the results for various subsamples. We start with periods that do no contain shock plans, namely 1974:1-1979:12 and 1974:1-1984:12. For the period 1974:1-1979:12 all tests agree on a non-rejection of the unit root hypothesis at any conventional significance level. For the period 1974:1-1984:12, the results are mixed, the ADF test does not allow for a rejection while the Z_α and MZ_α tests suggest a rejection at the 5% and 10% levels, respectively. Overall, the results suggest that the period prior to the shock plans and the high inflation is characterized by stochastic nonstationarity and persistence of shocks. This is confirmed by the estimate $\hat{f}_{\Delta y}(0)$ which is .75 for the period 1974:1-1979:12, again well above 0 (for the period 1974:1-1984:12 it is .74). It is important to note, however, that the non-rejections may be due to the well documented low power of unit root tests especially when using a short span of data (e.g. Perron (1991) and Shiller an Perron (1985)). This may indeed be the case given the fact that the estimate of the sum of the autoregressive coefficient is around .80 just as is the case for the full sample. Nevertheless, this possibility will not affect the main qualitative outcome of interest in comparing the results for the different subsamples.

We now turn to the results concerning the subsamples that contain shock plans. For illustration, we report results for the subperiods 1980:1-1994:6 and 1985:1-1994:6 but the qualitative outcome is the same using other subperiods containing plans. The results are very similar to those for the full sample. Most tests agree for a rejection of the unit root, the rejections being stronger using the sample 1980:1-1994:6.

It is of interest to note that the estimate of the measure of persistence $\hat{f}_{\Delta y}(0)$ is .92 (almost the same as that for the full sample). This value suggests substantial persistence of shocks contrary to the unit root tests. In particular, it is important to remark that the value of $\hat{f}_{\Delta y}(0)$ is higher when a strong rejection of the unit root occurs (i.e. when including the plans) than when a rejection is not possible (i.e. not including subperiods with plans). These results offers a conflicting picture of the properties of the data.

The results of this section suggest the following perplexing conclusion. The inflation rate is characterized by stochastic nonstationarity and persistence of shocks prior to the emergence of very high levels of inflation and the institution of the various shocks plans. The opposite holds for the period of high inflation with occasional shocks plans. For that period, fluctuations in inflation appear as stationary deviations around a stable linear trend function and shocks accordingly have effects that dissipate quickly (given the low value of the sum of the autoregressive coefficients).

The results for the interest rate series are presented in Table III. The conclusions are qualitatively identical in most aspects and the comments pertaining to the results for inflation apply equally well to those for the interest rate. The only differences are first that the unit root is rejected using the sub-period 74:1-79:12 but not 74:1-84:12. Secondly, for the sub-period 85:1-94:6, the Z_α and MZ_α tests fail to be significant at the 10% level, but the ADF test is still highly significant.

These results are perplexing because they are contrary to what intuition would suggest. Indeed, one would expect nonstationary (or erratic) behavior to occur especially in period of uncontrolled growth in inflation and failed attempt at stabilizing its level. Yet, standard tests suggest the opposite.

Our argument is that the results are simply artifacts created by the occasional presence of short but important shock plans. Indeed, the plans act in such a way that the level of the series is brought temporarily to a low level. Since the plans in the period considered have all failed quickly, inflation has returned to its old trend path. This is a manifestation of a mean-reverting behavior that also characterizes a stationary series. Since, the decreases and subsequent increases are so important they are likely to contaminate the statistical tests used. On the other hand, the empirical results indicate that the measure of persistence $\hat{f}_{\Delta y}(0)$ is not likely affected by the shock plans and offers a more accurate description of the persistence of shocks in the noise function characterizing the inflation and interest rate series.

The question of interest is then whether the series, in periods when shock plans are not into effect, are characterized by a trend path that is unstable (stochastically nonstationary with a unit root) or is even of an explosive nature. To answer this question, the tests used so far must be modified to isolate the effect of the shock plans. These modifications are the object of the next sections. Before presenting them, we first turn to the issue of the possible bias on the unit root tests and the measure of persistence caused by the shock plans.

5 Bias of Unit Root Tests in the Presence of 'Inliers'.

In this section, we present simple simulation experiments that aim at quantifying the bias on the size of the unit root tests and the mean of the persistence measure created by the presence of shock plans (or "inliers") that are short-lived but important in magnitude. The results will show how shock plans can create spurious mean-reverting behavior that would lead an investigator to conclude that the time series is stationary over the whole sample when using unit root tests. On the other hand the measure of persistence $\hat{f}_{\Delta y}(0)$ is immune to biases caused by the presence of shock plans.

5.1 Description of the experiments.

The data are first generated according to the following simple random walk with drift interrupted by occasional "inliers" or shock plans, referred to as case (1), :

$$\begin{aligned} y_t &= y_0 + \mu t + S_t && t = 1, ..., T \text{ and } t \notin \{t_{i,j}\}, \\ y_t &= a && \text{for } t \in \{t_{i,j}\}\ (j = 1, ..., p; i = 1, ..., n_j), \end{aligned} \tag{11}$$

where $S_t = \sum_{j=1}^{t} e_j$. Here $t_{i,j}$ refers to the time index of the i^{th} observation of plan j. There are p shock plans present and each plan contains n_j observations. The data-generating process described by (11) specifies that the time series is a random walk with drift μ except when a plan is in effect in which case the level of the series drops to a value a. To complete the specifications, the errors $\{e_t\}$ are independent $N(0, 1)$ random variables, the initial condition is $y_0 = a$ (so that the plans, in effect, bring the level of inflation to its initial value). We also considered a slight modification of this data-generating process when the plans bring the level of inflation to half its value the month before the plan. This is referred to as case (2) and is described by

$$\begin{aligned} y_t &= y_0 + \mu t + S_t && t = 1, ..., T \text{ and } t \notin \{t_{i,j}\}, \\ y_t &= y_{t_{1,j}-1}/2 && \text{for } t \in \{t_{i,j}\}\ (j = 1, ..., p; i = 1, ..., n_j). \end{aligned} \tag{12}$$

where $S_t = \sum_{j=1}^{t} e_j$. In both cases, we use the following specific values for the parameters. First $a = 4$ which can be viewed as an initial level of 4% for the inflation rate. There are $p = 3$ plans irrespective of the sample size and each plan contains $n_j = 6$ ($j = 1, 2, 3$) observations corresponding to plans lasting 6 months. A key parameter is the drift μ which specifies how fast the deterministic trend component increases. We consider four values ranging from mild to rapid growth: $\mu = .1, .2, .4$ and $.8$. The specification of this trend component is important because it basically dictates the magnitude of the decrease occurring with a shock plan. The faster the rate of growth, the larger the decrease and the likely importance of the spurious effect on the unit root tests. We consider three different sample sizes, $T = 150$, 250 and 500. Associated with each of these sample sizes are the starting dates of the plans. These are {40, 70, 120} for $T = 150$, {150, 170, 220} for $T = 250$, and {250, 350, 450} for $T = 500$. It is important to note that as the sample size increases the number of plans remains the same but the decreases caused by the plans are more important since they occur when the level of the series is higher.

Given the possibility that the noise component for Brazilian inflation and interest rate be explosive, we also considered experiments with such an explosive process interrupted by shock plans. The setup is exactly the same as described above except that the process describing the behavior of the series when shock plans are not in effect is given by:

$$\begin{aligned} y_t &= y_0 + \mu t + Z_t, \\ Z_t &= \alpha Z_{t-1} + e_t, \end{aligned} \tag{13}$$

with $Z_0 = 1$. In our experiments, we considered $\alpha = 1.01$ and $\alpha = 1.02$. All the other parameter configurations are exactly as for the unit root case. We, however, restrict the analysis to case (1) where the shock plans bring the level of the series to a fixed value a.

While these data-generating processes are simple they are rich enough to obtain a general overview of the bias on unit root tests caused by temporary shock plans or "inliers".

5.2 Description of the results.

We used 1,000 replications for each specifications of the two data-generating processes to compute the exact size of the unit root tests Z_α, MZ_α and ADF. The nominal size of the test is 5% and the critical values are taken from Fuller (1976) (−21.8 for

Z_α and MZ_α and -3.41 for ADF). We also report the mean and standard deviation of the statistics. The results for the unit root case are presented in Table IV.

We first note that in all cases the tests are severely oversized, so much as to be useless to provide a characterization of the nonstationary nature of the series. Consider the case of Z_α presented in panel (a). With a sample size $T = 150$ and a small drift $\mu = .1$, the test would incorrectly reject the unit root in favor of stationary deviations around a linear trend in 67% of the cases. This false rate of rejection increases as the drift μ and the sample size T increases, and quickly reaches 100% (for example when $\mu = .4$ and $T = 250$ which roughly characterizes the Brazilian inflation series). The rates of rejections are, of course, smaller when using the second data-generating process because the decrease in inflation caused by the plans are basically half of those in the first-data generating process. Still, the tests are again substantially oversized.

The same qualitative results hold for the tests MZ_α (panel (b)) and ADF (panel (c)). The rates of rejections are only marginally lower compared to those with Z_α. It is interesting to remark that the mean of the statistics seem to approach some limiting value as μ increases keeping a fixed sample size. This limiting value is well below the respective 5% critical value. The concentration also increases given that the standard error decreases. This implies a limiting rate of rejections of 100% as μ increases keeping T fixed but without the tests diverging to minus infinity. On the other hand, when μ is kept fixed and T increases the means of the statistics grow more negative (perhaps diverging to minus infinity) but the standard errors also increase. Whether this implies a limiting rate of rejection of 100% is a subject of interest for further theoretical investigations.

The results presented here clearly show that short but abrupt shock plans can bias the tests statistics against the unit root hypothesis in favor of stationary fluctuations around a stable linear trend function. This is an undesirable feature since the time span covered by the plans are very short compared to the whole sample (18 "months" in samples of 150 to 500 "months").

Consider now the behavior of the persistence measure $\hat{f}_{\Delta y}(0)$ in the presence of shock plans. The results are presented in panel (d) of Table IV. The results are clear, the presence of shock plans induces no discernible bias for any parameter configuration considered. Indeed, the persistence of shocks is more precisely estimated as the sample size increases, even if in that case more important temporary decreases are present. The absence of any important bias is easily understood given that the statistic is constructed using first-differences of the data. With first-differences, the shock plans appears simply as outliers at the beginning and end of the plans.

Table V presents the simulation results when the data are generated by an explosive process. Here, we present the probability of rejecting the null hypothesis of a unit root in favor of stationary fluctuations (along with the mean and standard error of the statistics). The results show again that, even with an explosive noise component, the presence of shock plans induces a strong bias in spuriously concluding that the process is trend-stationary. This bias increases as μ increases (in which case the shock plans are more important) but, unlike in the unit root case, decreases as the sample size increases. This false rejection in favor of stationary fluctuations also decreases as α, the explosive root, increases.

The simulation results presented in this section can help explain the rejections reported in the previous section for the Brazilian inflation and interest rates. Indeed, our experiments clearly show that shock plans induce a strong bias in unit root tests in concluding for stationary fluctuations whether the true noise component has a unit or explosive root. On the other hand, the measure of persistence $\hat{f}_{\Delta y}(0)$ is not affected. To verify the claim that the noise component of the inflation and interest rate series are not stationary, it remains to devise unit root tests that are immune to the presence of the shock plans. This is the object of the next section.

6 Corrected Versions of Unit Root Tests.

We now present modifications to the unit root tests that take into account the presence of the shock plans. The strategy is similar to that used in Perron (1989, 1990) in the case of permanent changes in level or slope of the trend function. The idea is to take the shock plans from the noise function to the trend function. More precisely, it is the movements in and out of the periods called "plans" that are isolated. This is not a statement about the deterministic nature of the timing and magnitude of the plans. Rather, it is to be viewed as a device to isolate their effect so that the tests can meaningfully assess the stochastic properties of the series when shock plans are not into effect. Since the timing of the plans are well documented and relates to governmental interventions, we treat the dates of their occurrence as known rather than as random variables to be estimated.

In is useful to first define some notations. Let $da(j)_t$ denote a dummy variable taking value 1 when the time index t corresponds to the first month when plan j takes effect, and 0 otherwise. Similarly, let $db(j)_t$ be a dummy variable taking value

1 when the time index t corresponds to the first month *after* the end of plan j, and 0 otherwise. Finally, let $D(j)_t$ be a dummy variable taking value 1 when the time index t correspond to one of the months when plan j is in effect, and 0 otherwise.

The modification to the ADF test is simply to include these dummies for each plan in the autoregression (2). Hence, the relevant regression is:

$$y_t = \eta + \gamma t + \sum_{j=1}^{p}(\kappa_j da(j)_t + \lambda_j db(j)_t + \phi_j D(j)_t) + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + v_t. \quad (14)$$

The test statistic is again constructed as the t-statistic for testing that α, the sum of the autoregressive coefficients, is unity. The number of lagged first-differences of the data, k, is again selected using the general to specific recursive procedure described before.

It is useful at this point to discuss the role played by the various dummies. First, note that $da(j)_t$ and $db(j)_t$ are used to allow removing the influence of the plans under the null hypothesis of a unit root. Note also that introducing $da(j)_t$ and $db(j)$ is sufficient if the alternative hypothesis of interest is that of an explosive process. On the other hand, $D(j)_t$ is used to remove the influence of the plans under the alternative hypothesis of stationarity. This can be seen by noting that, with a unit root or an explosive process, $da(j)_t$ acts as a one-time blip that becomes a permanent decrease in level (the beginning of the plan). The dummy $db(j)_t$ also acts as a one-time blip that becomes permanent thereby allowing an increase in level that marks the end of the plan. When the series is stationary, $D(j)_t$ acts as a temporary level shift that marks the occurrence of the plan.

The modifications to the test Z_α first involve using the following first-order autoregression:

$$y_t = \eta + \gamma t + \sum_{j=1}^{p}(\kappa_j da(j)_t + \lambda_j db(j)_t + \phi_j D(j)_t) + \alpha y_{t-1} + \nu_t. \quad (15)$$

Denote the OLS estimate of α by $\check{\alpha}$ and the sample variance of the residuals, $\check{\nu}_t$, by $\check{s}_u^2 = T^{-1}\sum_{t=1}^{T}\check{\nu}_t^2$. Also, denote by $\check{y}_{t-1}$ the residuals from the following regression:

$$y_{t-1} = \eta + \gamma t + \sum_{j=1}^{p}(\kappa_j da(j)_t + \lambda_j db(j)_t + \phi_j D(j)_t) + \xi_t, \quad (16)$$

i.e. $\check{y}_{t-1}$ are the residuals from a projection of y_{t-1} on a constant, a time trend and the relevant dummies associated with each plan. The modification to the autoregressive spectral density estimator of the residuals ν_t is different. Here, we need only consider the deterministic components that are relevant under the null hypothesis, namely the constant and the dummies $da(j)_t$ and $db(j)_t$. Denoting this estimator by $\breve{s}^2$, it is defined by (5) but with the autoregression (6) replaced by:

$$\Delta y_t = \eta + \sum_{j=1}^{p}(\kappa_j da(j)_t + \lambda_j db(j)_t) + b_0 y_{t-1} + \sum_{i=1}^{k} b_i \Delta y_{t-i} + e_{tk}. \tag{17}$$

The modified version of the Z_α and MZ_α tests can now be described as follows:

$$Z_\alpha C = T(\breve{\alpha} - 1) - (\breve{s}^2 - \breve{s}_u^2)/(2T^{-2}\sum_{t=1}^{T}\breve{y}_{t-1}^2), \tag{18}$$

and

$$MZ_\alpha C = (T^{-1}\breve{y}_T^2 - \breve{s}^2)/(2T^{-2}\sum_{t=1}^{T}\breve{y}_{t-1}^2), \tag{19}$$

or

$$MZ_\alpha C = Z_\alpha C + (T/2)(\breve{\alpha} - 1)^2. \tag{20}$$

6.1 Simulation results.

The modifications described above leave the asymptotic distributions of the unit root tests unchanged under the null hypothesis (compared to the unmodified statistics applied to series in the class described by (1)), provided the plans are treated as fixed in length as the sample size increases. However, for the asymptotic distributions to provide satisfactory approximations to the finite sample distributions, the shock plans must be of relatively short duration.

In this section, we present simulation results whose aim is first to verify if the usual asymptotic distribution provides a satisfactory approximation. Second, we inquire if indeed the modifications are effective in making the test immune to the presence of the shock plans. To do this, we examine the exact size of the modified tests using the same experiments as in Section 5 (exactly the same generated series are used). We also performed additional experiments where the processes are generated under the alternative hypothesis of trend-stationarity interrupted by shock plans. In this case, the data are generated using the same specifications except that the process describing the behavior of the series when no plans are in effect is given by:

$$y_t = a + \mu t + \alpha y_{t-1} + e_t, \tag{21}$$

instead of the random walk with drift described in (11) and (12). To examine the power of the modified test against stationary fluctuations, we specify $\alpha = .8$ and $.9$.

We also investigated power against explosive alternatives using the process described by (13) with $\alpha = 1.01$ and $\alpha = 1.02$.

The results for size are presented in Table VI and for power in Table VII. The first feature of interest is that the exact sizes of the tests are, in all cases, very close to the nominal 5% size (and insignificantly different from it). Hence, the modifications are successful in providing tests that are immune to the presence of shock plans and the usual asymptotic distribution provides a good approximation to the finite sample distribution. The second feature to note is that the tests still have reasonable power. Furthermore, the power function appears little influenced by different rates of growth and it increases rapidly as the sample size increases. We, therefore, conclude that the modifications are adequate. Comparing the different tests, we see that, with trend-stationary alternatives, the corrected versions of Z_α and MZ_α are more powerful than the corrected version of the ADF. When the alternative is that of an explosive process, the powers of the different tests are similar.

6.2 Empirical results.

We applied the modified unit root tests to the Brazilian inflation and interest rates series using the dates for the plans as specified in Table I. The results are presented in Table VIII (for inflation) and Table IX (for the interest rate) for the full sample and two subsamples (1980:1-1994:6 and 1985:1-1994:6). The results point to the same conclusion using any test and any sample, namely a strong rejection of the unit root but this time in favor of an explosive alternative.

There is, therefore, strong evidence that the shock plans are responsible for the spurious finding of a stationary behavior using standard tests and that once these are taken into account the evidence strongly supports an explosive path occasionally interrupted by shock plans.

7 Conclusions.

This paper has considered issues related to tests for a unit root and a measure of the persistence of shocks when a time series of data is contaminated by large level shifts that are of short duration. These temporary events are labelled as "inliers" or "shock plans" following our applications to the Brazilian inflation and interest rates series. We first show that standard unit root tests are severely biased in favor of rejecting the unit root against stationary fluctuations when shock plans are present (whether the noise component be characterized by a unit or explosive root). On the other hand, the measure of persistence constructed using first-differences of the data are immune to such a bias.

Hence, a practical recommendation is to complement the application of standard unit root tests with the calculation of measures of persistence. An outcome where the unit root tests reject in favor of stationary fluctuations and the measure of persistence is well above 0 can be a sign that the series is contaminated by "inliers" or "shock plans". To avoid the bias present when applying standard unit root tests, our study proposed corrected versions of three unit root tests. These corrected versions are shown to be adequate in terms of size and power.

The macroeconomic interpretation of our results is a support of the inflation inertia hypothesis which essentially states that shocks to inflation are highly persistent (see, among others, Arida and Lara-Resende (1985), Bacha (1988), Bresser Pereira and Nakano (1986), Lopes (1984), Modiano (1988), Novaes (1991), Pastore (1994) and Simonsen (1988)). This behavior of the inflation process is mainly explained by the widespread indexation to lagged inflation (backward looking indexation) and to a highly passive monetary policy that easily accommodated inflationary pressures while aiming at keeping unemployment low.

Note finally that, while the methodology developed in this paper is directly motivated by and applied to the Brazilian inflation and nominal interest rate series, the tools developed will be of direct application to a wide variety of cases where a series is affected by temporary but important events; for example, wars, strikes, etc.

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Table I: List of Shock Plans in the Brazilian Economy.

Name	Period	Length (months)	Decrease in Inflation (%)
Cruzado	86:3-86:10	8	14.03 (97.7%)
Bresser	87:7-87:9	3	16.75 (78.1%)
Summer	89:2-89:4	3	30.64 (86.4%)
Collor I	90:3-90:5	3	75.17 (95.8%)*
Collor II	91:2-91:6	5	9.53 (46.2%)

*For this plan, the decrease is computed over the two months from 90:02 to 90:04.

Table II: Empirical Results for Inflation.

Sample	Z_α	k	MZ_α	k	ADF			$\hat{f}_{\Delta y}(0)$	k
					$t_{\hat{\alpha}}$	$\hat{\alpha}$	k		
74:1-94:6	-37.03*	2	-33.97*	2	-4.95*	.81	2	.91	2
74:1-79:12	-9.67	2	-8.55	2	-2.65	.77	2	.75	2
74:1-84:12	-23.26*	4	-20.35**	4	-2.76	.83	4	.74	4
80:1-94:6	-29.62*	1	-26.97*	1	-5.38*	.76	1	.92	2
85:1-94:6	-20.10**	1	-18.16	1	-4.46*	.75	1	.92	2

*Significant at the 5% level against stationary alternatives.

** Significant at the 10% level against stationary alternatives.

For Z_α, MZ_α and $\hat{f}_{\Delta y}(0)$, the value of k in the autoregressive spectral density estimator is selected using the BIC criterion. For ADF, the value k is that obtained using the general to specific recursive procedure based on t-statistics on the last lags.

Table III: Empirical Results for Interest Rate.

Sample	Z_α	k	MZ_α	k	ADF			$\hat{f}_{\Delta y}(0)$	k
					$t_{\hat{\alpha}}$	$\hat{\alpha}$	k		
74:1-94:6	-32.82*	1	-30.57*	1	-5.44*	.82	1	.94	2
74:1-79:12	-34.55*	2	-24.33*	2	-1.36	.79	4	.68	2
74:1-84:12	-17.34	2	-15.99	2	-1.90	.91	4	.86	2
80:1-94:6	-26.19*	1	-24.14*	1	-4.91*	.79	1	.96	1
85:1-94:6	-17.75	1	-16.26	1	-4.09*	.78	1	.97	1

*Significant at the 5% level against stationary alternatives.

** Significant at the 10% level against stationary alternatives.

For Z_α, MZ_α and $\hat{f}_{\Delta y}(0)$, the value of k in the autoregressive spectral density estimator is selected using the BIC criterion. For ADF, the value k is that obtained using the general to specific recursive procedure based on t-statistics on the last lags.

Table IV: Exact Size of Unit Root Tests in the Presence of Shock Plans (5% Nominal Size).

(a) Z_α

	$T=150$			$T=250$			$T=500$		
	Size	Mean	s.e.	Size	Mean	s.e.	Size	Mean	s.e.
i) Case (1)									
$\mu=.1$	.67	-25.43	9.13	.82	-38.45	15.15	.92	-61.67	23.06
$\mu=.2$	.84	-29.09	7.58	.98	-49.90	9.45	1.00	-86.66	11.92
$\mu=.4$	.99	-33.13	3.70	1.00	-56.32	3.44	1.00	-97.71	3.94
$\mu=.8$	1.00	-34.57	1.50	1.00	-57.98	1.57	1.00	-100.82	1.46
ii) Case (2)									
$\mu=.1$	.41	-19.92	8.27	.64	-27.31	12.62	.77	-37.96	18.62
$\mu=.2$	.60	-23.28	7.66	.91	-37.48	10.92	.98	-63.49	16.97
$\mu=.4$	.90	-28.00	4.81	1.00	-47.99	5.80	1.00	-85.13	8.42
$\mu=.8$	1.00	-31.17	2.30	1.00	-52.28	2.71	1.00	-94.31	3.33

(b) MZ_α

	$T=150$			$T=250$			$T=500$		
	Size	Mean	s.e.	Size	Mean	s.e.	Size	Mean	s.e.
i) Case (1)									
$\mu=.1$	.62	-23.80	8.29	.81	-36.13	13.78	.92	-58.29	21.11
$\mu=.2$	.81	-27.09	6.82	.98	-46.45	8.45	1.00	-80.79	10.58
$\mu=.4$	.98	-30.69	3.28	1.00	-52.15	3.44	1.00	-90.46	3.42
$\mu=.8$	1.00	-31.95	1.32	1.00	-53.58	1.37	1.00	-93.15	1.26
ii) Case (2)									
$\mu=.1$	.36	-18.72	7.51	.61	-25.85	11.53	.76	-36.39	17.35
$\mu=.2$	.53	-21.76	6.88	.90	-35.05	9.77	.98	-59.82	15.34
$\mu=.4$	.85	-25.94	4.22	1.00	-44.35	5.80	1.00	-79.07	7.37
$\mu=.8$	1.00	-28.68	1.97	1.00	-48.06	2.31	1.00	-87.03	2.86

(c) *ADF*

		$T = 150$			$T = 250$			$T = 500$	
	Size	Mean	s.e.	Size	Mean	s.e.	Size	Mean	s.e.
i) Case (1)									
$\mu = .1$	.40	-3.42	1.26	.63	-4.65	1.74	.89	-6.06	1.99
$\mu = .2$	.64	-4.11	1.32	.92	-6.10	1.23	1.00	-8.27	1.03
$\mu = .4$	.91	-5.05	0.83	1.00	-6.96	.38	1.00	-9.22	0.33
$\mu = .8$	1.00	-5.42	0.18	1.00	-7.17	.17	1.00	-9.49	0.12
ii) Case (2)									
$\mu = .1$	.27	-2.96	1.07	.43	-3.64	1.39	.68	-4.21	1.51
$\mu = .2$	.39	-3.37	1.24	.70	-4.78	1.53	.97	-6.39	1.66
$\mu = .4$	.65	-4.18	1.23	.96	-6.35	.93	1.00	-8.43	0.72
$\mu = .8$	.95	-5.15	0.62	1.00	-7.00	.34	1.00	-9.24	0.29

(d) $\hat{f}_{\Delta y}(0)$

	$T = 150$		$T = 250$		$T = 500$	
	Mean	s.e.	Mean	s.e.	Mean	s.e.
i) Case (1)						
$\mu = .1$	.99	.13	1.00	.08	1.01	.04
$\mu = .2$	1.01	.08	1.01	.04	1.01	.02
$\mu = .4$	1.02	.04	1.01	.02	1.01	.01
$\mu = .8$	1.02	.02	1.01	.01	1.01	.004
ii) Case (2)						
$\mu = .1$	.99	.15	1.00	.10	1.00	.06
$\mu = .2$	1.01	.11	1.01	.06	1.01	.03
$\mu = .4$	1.02	.06	1.01	.03	1.01	.02
$\mu = .8$	1.02	.03	1.01	.02	1.01	.01

Table V: Probability of Rejecting in Favor of Stationarity when the Noise Function is Explosive; Case (1)

(a) Z_α

	$T = 150$			$T = 250$			$T = 500$		
	Size	Mean	s.e.	Size	Mean	s.e.	Size	Mean	s.e.
i) $\alpha = 1.01$									
$\mu = .1$	.71	-26.43	8.64	.85	-38.21	13.48	.48	-22.73	12.77
$\mu = .2$	.83	-28.91	7.76	.84	-41.78	15.27	.61	-25.95	19.36
$\mu = .4$	.97	-32.86	4.57	.91	-48.93	14.31	.64	-32.10	26.44
$\mu = .8$	1.00	-34.58	1.57	1.00	-56.42	5.03	.71	-43.94	31.77
ii) $\alpha = 1.02$									
$\mu = .1$	.36	-19.66	7.29	.11	-16.02	7.42	.00	2.54	1.02
$\mu = .2$	.54	-20.69	9.34	.23	-17.64	10.87	.00	2.54	1.16
$\mu = .4$	.77	-24.54	10.66	.38	-19.96	15.22	.00	2.49	1.28
$\mu = .8$	.92	-30.22	7.37	.64	-26.48	18.29	.01	2.01	6.16

(b) MZ_α

	$T = 150$			$T = 250$			$T = 500$		
	Size	Mean	s.e.	Size	Mean	s.e.	Size	Mean	s.e.
i) $\alpha = 1.01$									
$\mu = .1$	.67	-24.70	7.83	.84	-35.90	12.32	.43	-22.15	12.77
$\mu = .2$	.81	-26.95	7.01	.84	-35.08	13.95	.59	-25.10	18.12
$\mu = .4$	.96	-30.47	4.10	.91	-45.51	13.06	.64	-30.71	24.67
$\mu = .8$	1.00	-34.58	1.57	1.00	-52.24	4.49	.71	-41.63	29.51
ii) $\alpha = 1.02$									
$\mu = .1$	.30	-18.62	6.66	.10	-15.55	6.93	.00	2.55	1.01
$\mu = .2$	.46	-19.50	8.61	.21	-17.01	10.14	.00	2.55	1.15
$\mu = .4$	.75	-22.95	9.82	.36	-19.08	14.18	.00	2.49	1.28
$\mu = .8$	.92	-28.11	6.72	.63	-25.06	16.98	.01	2.05	5.78

(c) *ADF*

	$T = 150$			$T = 250$			$T = 500$		
	Size	Mean	s.e.	Size	Mean	s.e.	Size	Mean	s.e.
i) $\alpha = 1.01$									
$\mu = .1$	.50	-3.69	1.34	.64	-4.71	1.69	.09	-2.66	1.08
$\mu = .2$	.65	-4.14	1.31	.74	-5.22	1.87	.18	-2.84	1.69
$\mu = .4$	.90	-4.97	0.88	.86	-6.04	1.75	.36	-3.28	2.40
$\mu = .8$	1.00	-5.41	0.20	.98	-6.94	0.69	.61	-4.24	2.97
ii) $\alpha = 1.02$									
$\mu = .1$	.14	-2.48	1.01	.04	-1.99	0.79	.00	0.63	0.15
$\mu = .2$	.21	-2.62	1.34	.07	-2.12	1.22	.00	0.63	0.21
$\mu = .4$	.47	-3.36	1.74	.14	-2.32	1.79	.00	0.62	0.22
$\mu = .8$	.82	-4.57	1.35	.30	-3.05	2.29	.00	0.58	0.67

Table VI: Exact Size of Corrected Unit Root Tests with Shock Plans. (5% Nominal Size)

(a) $Z_\alpha C$

	$T=150$		$T=250$		$T=500$	
	Left	Right	Left	Right	Left	Right
i) Case (1)						
$\mu = .1$	.059	.075	.063	.076	.057	.047
$\mu = .2$	.074	.064	.065	.048	.074	.054
$\mu = .4$	.066	.076	.071	.048	.052	.049
$\mu = .8$	.068	.061	.059	.050	.053	.055
ii) Case (2)						
$\mu = .1$	.075	.065	.065	.063	.034	.070
$\mu = .2$	.070	.073	.057	.067	.058	.042
$\mu = .4$	.069	.060	.071	.064	.065	.053
$\mu = .8$	.064	.059	.066	.047	.053	.042

(b) $MZ_\alpha C$

	$T=150$		$T=250$		$T=500$	
	Left	Right	Left	Right	Left	Right
i) Case (1)						
$\mu = .1$	.047	.077	.058	.076	.055	.047
$\mu = .2$	.056	.064	.051	.048	.066	.054
$\mu = .4$	.048	.076	.057	.048	.047	.049
$\mu = .8$	.052	.063	.049	.051	.050	.056
ii) Case (2)						
$\mu = .1$	.060	.065	.056	.064	.031	.070
$\mu = .2$	.056	.073	.048	.067	.050	.042
$\mu = .4$	.046	.060	.059	.064	.062	.053
$\mu = .8$	.048	.059	.056	.047	.048	.042

(c) *ADFC*

	$T = 150$		$T = 250$		$T = 500$	
	Left	Right	Left	Right	Left	Right
i) Case (1)						
$\mu = .1$	.057	.111	.057	.092	.059	.046
$\mu = .2$	.061	.106	.061	.050	.071	.058
$\mu = .4$	.061	.094	.048	.057	.048	.056
$\mu = .8$	.048	.086	.045	.070	.042	.060
ii) Case (2)						
$\mu = .1$	.069	.098	.059	.076	.044	.071
$\mu = .2$	.053	.098	.053	.066	.042	.047
$\mu = .4$	.049	.081	.060	.073	.067	.061
$\mu = .8$	.049	.087	.052	.074	.047	.048

Table VII: Power of the Corrected Unit Root Tests with Shock Plans; Case (1).

(a) $Z_\alpha C$

	$T=$ 150				$T=$ 250				$T=$ 500			
$\alpha=$	.8	.9	1.01	1.02	.8	.9	1.01	1.02	.8	.9	1.01	1.02
$\mu=.1$	.97	.50	.09	.69	1.00	.89	.49	.97	1.00	1.00	.97	1.00
$\mu=.2$	.98	.55	.11	.70	1.00	.90	.52	.96	1.00	1.00	.98	1.00
$\mu=.4$	.98	.53	.09	.70	1.00	.91	.49	.96	1.00	1.00	.97	1.00
$\mu=.8$	.97	.52	.08	.70	1.00	.92	.45	.95	1.00	1.00	.95	1.00

(b) $MZ_\alpha C$

	$T=$ 150				$T=$ 250				$T=$ 500			
$\alpha=$	.8	.9	1.01	1.02	.8	.9	1.01	1.02	.8	.9	1.01	1.02
$\mu=.1$	.94	.42	.09	.69	1.00	.86	.49	.97	1.00	1.00	.97	1.00
$\mu=.2$	.96	.48	.11	.70	1.00	.88	.52	.96	1.00	1.00	.98	1.00
$\mu=.4$	.96	.47	.09	.70	1.00	.89	.49	.96	1.00	1.00	.97	1.00
$\mu=.8$	.97	.44	.08	.70	1.00	.90	.45	.95	1.00	1.00	.95	1.00

(c) $ADFC$

	$T=$ 150				$T=$ 250				$T=$ 500			
$\alpha=$	.8	.9	1.01	1.02	.8	.9	1.01	1.02	.8	.9	1.01	1.02
$\mu=.1$	.80	.29	.12	.70	1.00	.71	.50	.96	1.00	1.00	.97	1.00
$\mu=.2$	.87	.36	.12	.70	1.00	.77	.51	.97	1.00	1.00	.98	1.00
$\mu=.4$	.86	.34	.10	.70	1.00	.75	.48	.97	1.00	1.00	.97	1.00
$\mu=.8$	.83	.29	.12	.71	1.00	.76	.45	.96	1.00	1.00	.95	1.00

Table VIII: Empirical Results for Corrected Unit Root Tests on Inflation.

Sample	$Z_\alpha C$	k	$MZ_\alpha C$	k	$ADFC$		
					$t_{\hat{\alpha}}$	$\hat{\alpha}$	k
74:1-94:6	9.59*	2	9.72*	2	2.88*	1.08	4
80:1-94:6	6.46*	2	6.53*	2	2.35*	1.09	4
85:1-94:6	5.72*	2	5.82*	2	2.74*	1.13	4

*Significant at the 1% level against explosive alternatives.
For $Z_\alpha C$, and $MZ_\alpha C$, the value of k in the autoregressive spectral density estimator is selected using the BIC criterion. For ADF, the value k is that obtained using the general to specific recursive procedure based on t-statistics on the last lags.

Table IX: Empirical Results for Corrected Unit Root Tests on Interest Rate.

Sample	$Z_\alpha C$	k	$MZ_\alpha C$	k	$ADFC$		
					$t_{\hat{\alpha}}$	$\hat{\alpha}$	k
74:1-94:6	-1.09*	2	-1.09*	2	1.32*	1.05	5
80:1-94:6	-2.89**	2	-2.87**	2	1.47*	1.07	4
85:1-94:6	-1.10*	2	-1.09*	2	1.54*	1.08	2

*Significant at the 5% level against explosive alternatives.
**Significant at the 10% level against explosive alternatives.
For $Z_\alpha C$, and $MZ_\alpha C$, the value of k in the autoregressive spectral density estimator is selected using the BIC criterion. For ADF, the value k is that obtained using the general to specific recursive procedure based on t-statistics on the last lags.

Figure 1: Brazilian Inflation Rate, 1974:1–1994:6

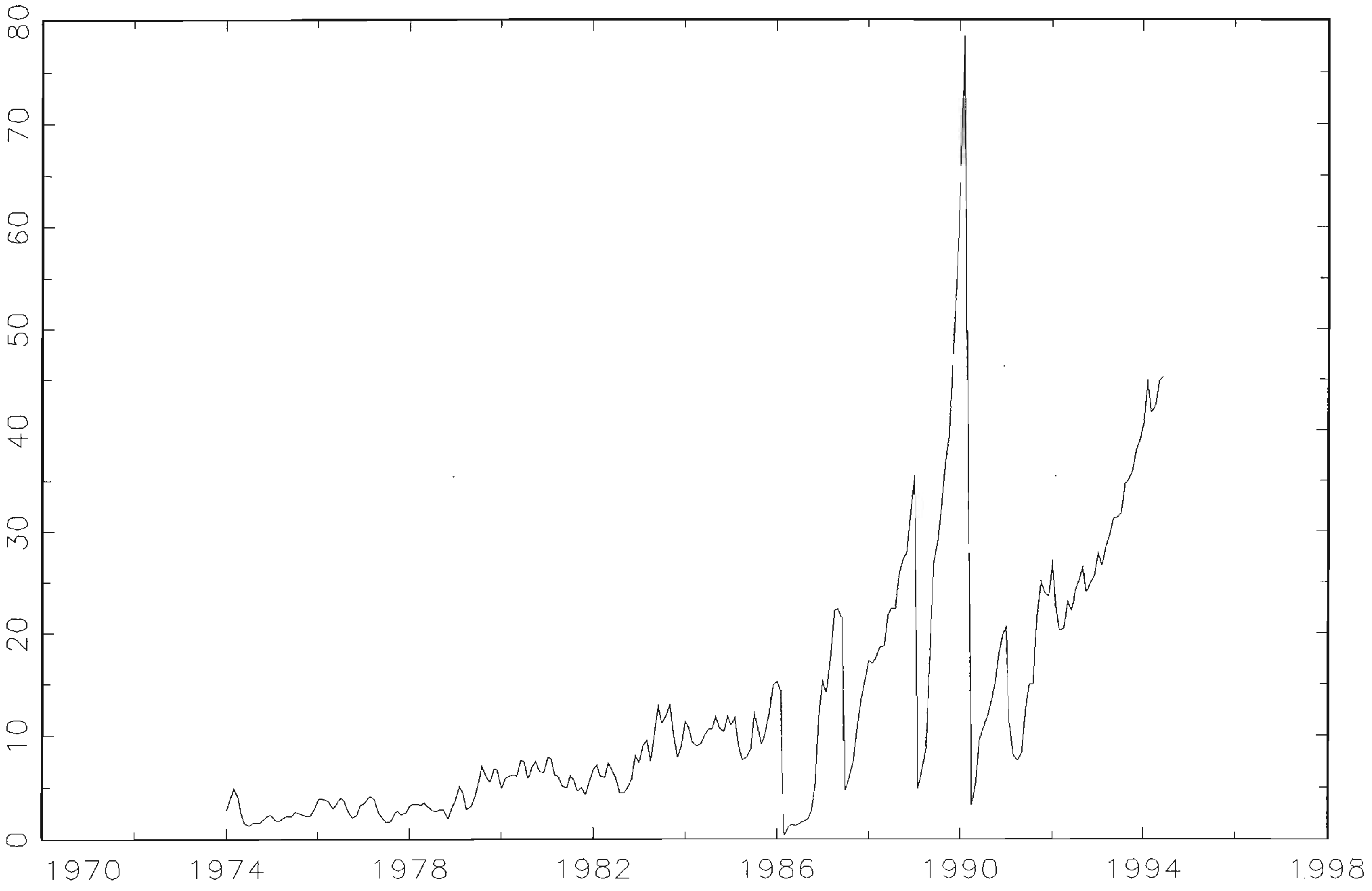
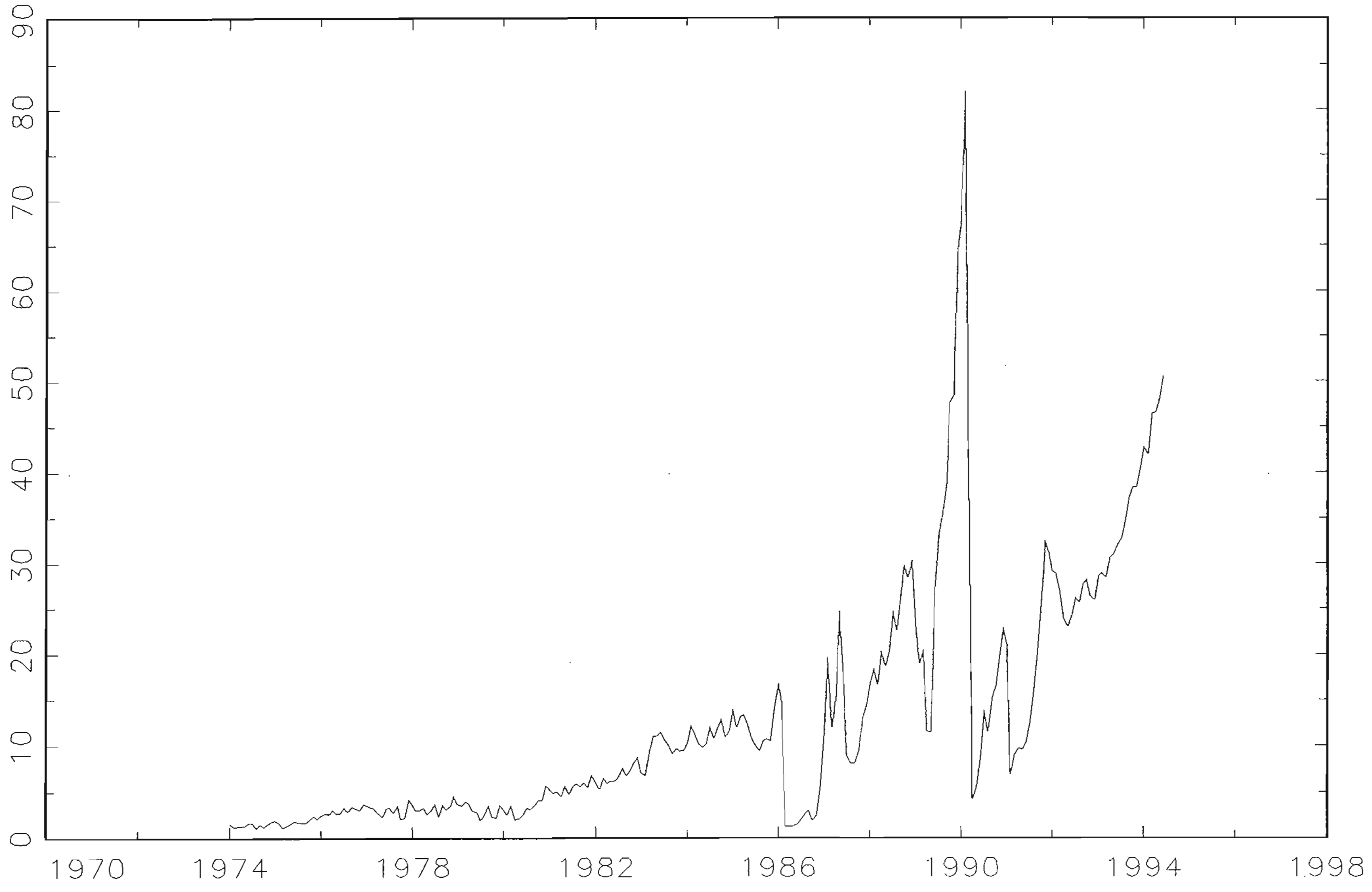


Figure 2: Brazilian Nominal Interest Rate, 1974:1 – 1994:6



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