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TESTING THE ORDER OF INTEGRATION WITH LOW POWER TESTS. AN APPLICATION TO ARGENTINE MACRO-VARIABLES

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The low power of available econometric tests is an important problem in applied research on unit roots and related issues. Based on the principle of methodological triangulation, the problem should be analyzed from different points of view in order to increase the validity of the results. Following this approach a strategy to test the order of integration in time series is presented using a sequence of eleven consolidated tests. In this way it is possible to determine the persistence of shocks, to specify the best strategy for trend-cycle decomposition and to obtain additional information useful for public policies. As an application of the methodology, the integration properties in the main 14 Argentine macroeconomic variables are studied. A classification of them in four homogenous groups according to their order of integration is obtained.

JEL classification codes: C3, C5, E3
Key words: unit root, persistence, cycles, structural breaks, Argentine macroeconomic variables

I. Introduction

Both for political purposes and academic issues, the appropriate estimation of the order of integration in macroeconomic time series is a key procedure to asses the degree of shock persistence and to determine the main features in trend-cycle decomposition methods.

However, the available kind of information and the low power in current econometric tools reduce the validity of (and confidence on) applied

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conclusions.[1] Specifically, there is no unique test that could guarantee an uncontroversial result. There are different problems that need different treatment in order to avoid an erroneous final result. Nevertheless, it is possible to define a minimum set of tests in order to cover a wide range of possible results with the hope of providing a useful tool for practitioners.

The main objective of this paper is to propose a methodology to test the order of integration of the series from different points of view, including the traditional unit root tests and other recent econometric developments. In order to explain our proposal we present an application of the methodology to some of the most relevant macroeconomic variables for Argentina.

The rest of the paper is organized as follows. Section II presents a discussion on the relationship between Data Generating Process (DGP) and the order of integration. Section III explores different alternatives to identify the DGP. Section IV introduces a methodology based on the principle of methodological triangulation. Section V applies the procedure to the main Argentine macroeconomic time series. Finally, in Section VI, the conclusions are presented.

II. DGP and the Order of Integration

A series that needs to be differentiated k times to acquire stationarity is considered to be integrated of order k: I(k). For example, a series as follows:

$$y_t = \alpha + \rho\, y_{t-1} + \varepsilon_t \tag{1}$$

given that ε are independent and identically distributed (i.i.d.) errors, when $\rho = 1$ is non-stationary. This is known as a random walk with drift process.

The series turns into a stationary one when it is differentiated (in the case

[1] Cochrane (1991) remarked on the low power of the unit root tests, as well as of any other test where a null hypothesis of $\rho = \rho_0$ against the alternative $\rho_{0-\kappa}$ with κ small for reduced samples. Although the difference between ρ_0 and $\rho_{0-\kappa}$ could be reduced and be even insignificant from the economic point of view, this is especially problematic in the case of unit root tests, for there exists a discontinuity in the theory of distribution in vicinity of the unit root. Thus, in such cases, these tests would not answer the question about which is the most appropriate distribution for small samples.

of equation 1 only once), so the DGP of this series is said to be a Difference-Stationary Process (DSP). This kind of series is also said to present stochastic non-stationarity (Charenza and Deadman, 1997) and can be adequately modeled as a unit root process in the autoregressive terms.

Nelson and Plosser (1982) in their pioneering work for the United States, show that 13 out of the 14 macroeconomic series they studied present stochastic non-stationarity, specifically that they are I(1), that is they have a stochastic trend and thus are to be modeled as unit root processes.

However, when the series is of the kind:

$$y_t = \alpha + \delta t + \varepsilon_t \qquad \text{with } \varepsilon_i \text{ i.i.d.} \sim N(0, \sigma^2) \qquad (2)$$

y_t is a stationary series around a deterministic trend. Stationarity is achieved by subtracting the deterministic component (in equation 2, $\alpha + \delta t$) from y_t. The process behind this kind of series is called a Trend-Stationary Process (TSP). This is an I(0) series, so it does not need to be differentiated to make it stationary. This was the traditional way of treating the series until Nelson and Plosser's work came out. Maddala and Kim (1998) state that from the numerous empirical works in existence, it is apparent that the deterministic trend is most common amongst real variables rather than nominal ones.

In a TSP the effect of shocks vanishes in the long run when t moves farther away from the moment of the shock. With DSP the effect of the shock remains. Making a mistake in the determination of the DGP could lead to important errors. If the series is a TSP and we differentiate it we will be over-differentiating the series, and if the original series is a DSP and we treat it as a TSP, when running the regression against time we will be under-differentiating, allowing spurious periodicity in the cyclical component (Nelson and Kang, 1981).[2]

III. Shock Persistence, Trend-Cycle Decomposition and Policy Intervention

Table 1 presents a synthesis of existing views about the relationship

[2] However, Plosser and Schwert (1978) state that the risk of over-differentiating is not so great if we analyze the properties of the residuals of the regression carefully.

Table 1. A Synthesis of the Different Views

Duration of the shocks	Persistence	Order of integration of the series	Trend	Kind of trend	Cycle	Recommended policy
Transitory	Low	I(O)	Deterministic	Linear, exponential	Greater amplitude	Countercyclical
Permanent	High	I(k) with k ≥ 1	Stochastic	ARIMA models (RW, etc.)	Very small or not existent	Structural reform
Transitory and a few permanent	Low	I(O)	Segmented deterministic	One or several breaks	Greater amplitude	Structural reform and countercyclical

between the order of integration in macroeconomic time series, the persistence of their shocks and its effect on trend cycle-decomposition procedures.

An I(1) series implies that each shock is permanent and trend is stochastic. On the other hand, an I(0) series suggests that shocks hitting the economy do not make it deviate permanently from its long run deterministic path.

Assuming a segmented deterministic trend implies that the majority of the shocks are transitory and that only very few are permanent (these are the structural breaks that sporadically hit the economy). The "resurrection" of the deterministic trend, even though segmented, to the core of the discussion has great implications with respect to the role of shocks and of stabilization policies. Accordingly, it has been the source of great controversy, giving rise to a set of comparative studies on previous works on unit root and allowing the possibility for gaining greater precision in the specification and knowledge of the macroeconomic time series.

The importance of an appropriate characterization of the cyclical and trend components in the main variables of an economy is based upon the need to optimize the stock of information for policymakers. The results that derive from this kind of analysis can be used to evaluate the benefits of different kinds of policies (for example, countercyclical versus structural),[3] to estimate the suitable time for implementation (since the identification of different phases of the business cycle is particularly sensitive to the specification of the deterministic component of the series), and even to evaluate the intensity of the policies (since the length of the cycles also depends upon the characteristics of the DGP).[4]

The previous statements are more relevant in the case of developing economies where the answers to the questions such as which type of policy to

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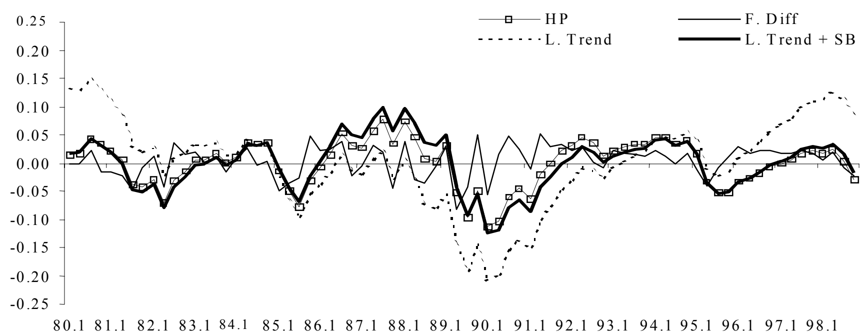
[3] When shocks are mainly permanent (caused by real factors) countercyclical or stabilization policies can never be successful. In this situation Cribari-Neto (1993) pointed out "... since short term stabilization policies are designed to neutralize the effects of transitory disturbances...[they] are bound to be ineffective...this suggests that government should concentrate its efforts on long term policies." On the other hand, the existence of structural breaks and transitory shocks (when other things remain equal) increases the probability that a successful intervention should involve structural reforms.

[4] For a deeper analysis of the influence of the detrending methodology on the main characteristics of the business cycle, see Canova (1998).

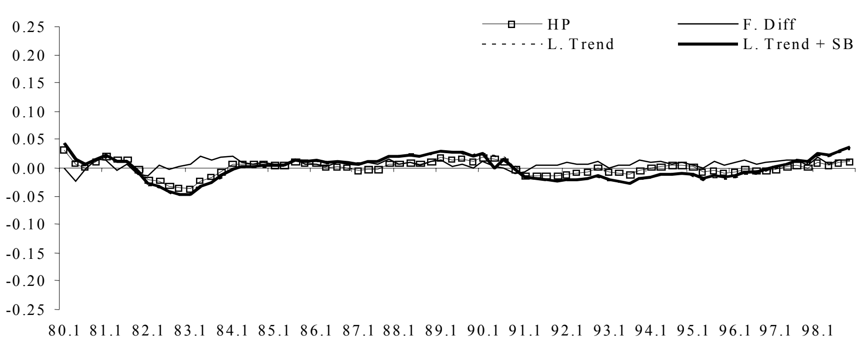
implement, when to implement it and with what degree of intensity, appear to be more sensitive to the specification of the cyclical and trend components of the variables under study. This can be seen by comparing the evolution of the cycle of GDP in Argentina and the USA for the period 1980:1-1999:4, with four different specifications for the trend component: linear deterministic, linear deterministic with structural breaks, traditional stochastic (the cycle results from the first differences of the series) and smoothed moving averages (where the trend results from the HP filter (Hodrick and Prescott, 1980)).

Figure 1. The GDP Cycle According to Different Methodologies. Argentina and USA

(a) Argentina's GDP Cycles



(b) USA's GDP Cycles



We can see that second moments (variance and covariance) as well as the persistence of the cycles for Argentina change much more than in the case of the USA when the specification of the trend component is changed. Thus the volatility of the cycle of GDP[5] in Argentina can change from 3,2% to 8,2% while the same measure in the United States goes from 0.9% to 2.3%, depending on the method for de-trending. However, the relative volatility is almost the same: 2.5 in both countries.

Also, the specification of the trend component of the series influences very significantly the identification of different business cycles that appear at certain periods of time. As an example, we can look at the case of Argentina from the data that is presented in Table 2.

Table 2. Argentina's GDP Cycle According to Different Detrending Methodologies

	Detrending methodology			
Cycle stage	Linear trend	Linear trend with S. break	HP Filter	First difference
Beginning of recessions	84:4; 88:1; 95:1	81:2; 84:4; 88:2; 95:1; 98:4	81:3; 84:4; 89:1; 95:1; 99:1	80:3; 84:4; 87:2; 92:2; 94:4; 98:2
Beginning of expansions	87:1; 93:2; 95:4	84:1; 86:2; 91:2; 96:1	82:4; 86:1; 91:2; 96:4	82:2; 85:3; 90:1; 92:4; 95:3

It is easy to see that there are outstanding differences in the peaks and valleys that can be recorded depending on the type of trend component that it is used for the extraction of the cycle of the GDP. These examples give an intuition of the usefulness of the study we will be developing in this paper.

IV. Alternative Ways of Identifying the Order of Integration

The literature offers several low power tests to study the order of integration

[5] Measured as the standard deviation of the series.

in time series. This leads to an eclectic position as regards the "different perspectives of reality" which lie behind the assumptions of the different tests.[6] These partial, and for that reason incomplete, visions can be improved through a process called methodological triangulation. Hammersley and Atkinson (1983) state that "what is involved in methodological triangulation is not the combination of different types of methodologies per se, but to correct the potential weaknesses that may limit the validity of the analysis." For Fielding and Fielding (1986), the conventional idea of triangulation is that if diverse types of data or methods sustain the same conclusion, the trustworthiness of the results is increased.

One of the first approximations to methodological triangulation in social sciences has been the work of Campbell and Fiske (1959) who proposed the use of matrices (multi-trait multi-method) to verify the validity of the conclusions in their investigation, through the correlation of the results of several tests applied to the same subjects studied.

We will follow Campbell and Fiske's (1959) approach by analyzing the results of the different tests first separately and later evaluating the degree of coincidence of these results in a general matrix. Our methodological choice lays on the nature of the information used in most of the empirical applications. The data, a segmented and partially inexact sample of reality, leads us to doubt the acceptance of the underlying hypothesis of the different tests that could be applied in a particular analysis.

In the specific case of this study, one could say that, if we accept the hypothesis of structural breaks in the data generating process, the only results to be taken into account should be those that allow for the inclusion in their functional form of a segmented deterministic trend. Under such circumstances, it would seem that it makes no sense to evaluate the correlation of the results of tests with a mutually excluding hypothesis.

However, this conception of the methodological procedure is not appropriate as long as there is "uncertainty" associated with the hypothesis of different low power tests.[7] For this situation, we recommend the use of a

[6] For Fielding and Schreier (2001) every method imposes a "perspective" of reality and for that reason they have something different to say of the symbolic reality (interpreted by the researcher).

[7] For example, it is possible that what seems to be a structural break is only a transitory

process of multiple methodological triangulation such as the one we use in the empirical section.

A. Traditional Tests of Unit Roots

Nelson and Plosser (1982) demonstrated that a time series has a stochastic trend if and only if it has a Unit Root (UR) in the autoregressive component. In this way, testing for the number of UR is equivalent to testing the existence of a stochastic trend.

Based on the fact that the parameter *d* in an ARIMA (*p, d, q*) representation is equal to the number of unit roots, Dickey and Fuller constructed a test on the null hypothesis of UR.[8] This is the so-called Dickey-Fuller (DF) test. It is based on the restrictive assumption of independent and identically distributed (i.i.d.) errors.

One weakness of the DF test is that it doesn't take into account the possible autocorrelation between errors ε_t.[9] If this were the case, the Ordinary Least Squares (OLS) estimations or its substitutes would not be efficient. The solution, implemented by Dickey and Fuller (1981), was to include an explanatory variable, the lagged dependent variable. This solution is known as the Augmented Dickey-Fuller test (ADF). The mechanism consists in testing the null of $\xi = 0$ in the OLS regression in the following equation:

$$\Delta y_t = \xi\, y_{t-1} + \sum_{i=1}^{k} \xi_i \Delta y_{t-1} + \varepsilon_t \qquad (3)$$

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shock that, if it appears near the extremes of the sample, could appear to be permanent. Or it could also be the case that the structural break be an artifact of the frequency of the data. Take for example the case of daily data. A shock could increase the level of the series for a couple of months (say, ninety days). If the sample includes only 365 days (one year) this shock could be seen as two structural breaks (one when it appears and another when the effects cease). But, when we transform the series to a quarterly frequency, the shock appears to be an outlier that no one would dare compare to a structural break.

[8] *p* indicates the order of integration of the autoregressive component, *q* is the moving average component and *d* the number of times the variable has been differentiated to reach stationarity.

[9] For an accurate criticism of some of the problems of the tests based on the DF methodology see Maddala and Kim (1998).

Phillips (1987) and Phillips and Perron (1988) proposed a new test using a non-parametric correction for the presence of serial correlation. The objective was to eliminate the nuisance parameters on the asymptotic distribution caused by the presence of serial correlation in the errors ε_t.

Another alternative to test unit root consists in evaluating the shifting root hypothesis. For this purpose the rolling estimation developed by Banerjee, Lumsdaine and Stock (1992) provides a complete set of analysis. Applied to the unit root hypothesis, the procedure consists on developing a rolling estimation of the maximum and minimum ADF t statistics and comparing them with the 5% asymptotic critical values. In addition, we analyze the difference between the maximum and minimum ADF statistics, which can be associated with a measure of shifting root or root volatility. Unlike recursive estimation, rolling parameters are computed using sub-samples that are a constant fraction δ_0 of the full sample. In this way we can keep constant the marginal weight of each observation.[10]

B. Stationarity Test. KPSS Test

Kwiatkowski, Phillips, Schmidt and Shin (1992) have proposed a test for stationarity as null. They start with the following model:

$$y_t = \delta t + \varsigma_t + \varepsilon_t \tag{4}$$

where ε_t is a stationary process and ς_t is a random walk given by:

$$\varsigma_t = \varsigma_{t-1} + \mu_t, \qquad \mu_t \sim \text{i.i.d. } (0, \sigma_u^2) \tag{5}$$

The null hypothesis of stationarity is formulated as

$$H_0 : \sigma_u^2 = 0 \quad \text{or} \quad \varsigma_t \text{ is a constant} \tag{6}$$

This is a special case of a test for parameter constancy against the alternative

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[10] The recursive methodology derived from Brown, Durbin and Evans (1975) consists in estimating a parameter using sub-samples t = 1,....,k, for k = k_0 ,...,T, where k_0 is the start–up value and T is the full sample size.

that the parameters follow a random walk. This problem is discussed by Nabeya and Tanaka (1988), who develop a statistic to test the KPSS test hypothesis. The statistic is given by

$$LM = \frac{\sum_{t=1}^{T} S_t^2}{\hat{\sigma}_e^2} \tag{7}$$

where $\hat{\sigma}_e^2$ is the residual variance from this regression and S_t is the partial sum of e_t defined by

$$S_t = \sum_{i=1}^{t} e_i, \qquad t = 1, 2, \ldots, T \tag{8}$$

where e_t are the residuals from a regression of y_t on a constant and a time trend.

The asymptotic distribution of the LM test statistic has been derived in Nabeya and Tanaka (1988). However, this is valid only if the errors are i.i.d.. Kwiatkowski et al. (1992) consider the case of a general error process and hence modify the test statistic as in Phillips (1987) and Phillips and Perron (1988). They then derive the asymptotic distribution of the modified statistic and tabulate the critical values by simulation.

C. Variance Ratio Measurement (VR)

An alternative non-parametric instrument to evaluate the presence of a unit root is to measure the degree of persistence. Cochrane (1988) proposed such alternative. Using the Beveridge and Nelson (1981) decomposition we can see that each series can be modeled as a combination of a non-stationary random walk (RW) and a stationary component. However, the RW can have an arbitrarily low variance, so that the power of the UR tests is arbitrarily low for small samples.

Cochrane (1991) highlights the importance of measuring the size of the RW component through the degree of persistence of shocks in the levels of the series. The measurement presented by Cochrane (1988) is as follows:

$$VR_k = \frac{V_k}{V_1} = \frac{\text{var}(y_t - y_{t-k})}{k\,\text{var}(y_t - y_{t-1})} \tag{9}$$

If y_t is stationary, then $\lim_{k\to\infty} VR_k = 0$ and if y_t is a RW, $VR_k = 1$ for any lag size. In practice, several values for VR_k are considered to analyze if the null should be rejected (Maddala and Kim, 1998).

Lo and MacKinlay (1988) and Campbell, Lo and MacKinley (1997) have proposed a modification to the test which takes into account the effect of the existence of the heterocedasticity in the series, on the probability of rejection of the null hypothesis of unit root. The authors state that if the usual variance ratio test is applied to such a series, the instability of the volatility through time could result in the artificial rejection of the null hypothesis. To overcome this problem, it is possible to use the procedure developed by White and Domowitz (1984) who corrected the critical values of the test for the estimation of a heterocedastic-consistent variance, so these values warrant an asymptotically normal distribution.

D. Unit Root under the Hypothesis of a Structural Break

The idea of a structural break is associated with changes of the parameters in a regression. Discussions on the constancy of parameters have been very rich in econometrics, with a great number of tests developed in this respect (for a review and classification see Maddala and Kim, 1998). The point that we are interested to focus in is how structural changes can affect the results of the unit root tests.

A pioneering article on the subject was one by Perron (1989) where he argues that, in general, shocks are transitory and the series are sporadically hit by extraordinary (not regular) events. Since its probability distribution is different from that of other regular shocks, he proposes changing them from the noise component to the deterministic trend of the series.

In other words, innovations are transitory (and so stationary) around a deterministic trend that can sporadically suffer changes of different kinds (in the intercept, in the slope, or both). Perron's proposal is very powerful and brings back into discussion what had been consolidated as the dominant framework in the 80s on the existence of a stochastic trend in the majority of the economic time series. That is, that they were generated by a DSP.

For example, the existence of a structural break represented by a change in the value of the mean in a series could make the conventional analysis conclude that there exists a unit root, when in reality none exists. It is just that the series was and still is stationary, but now around a new mean.

In this case, in the presence of a structural break, the tests of the Dickey-Fuller kind tend to accept the null hypothesis of a unit root when actually the process is stationary to both sides of the structural break.

From Perron's work onwards, there has been a long sequence of tests that have gained in complexity. Perron (1989) proposes a modified DF test for unit root in the *noise function* with three different alternatives for the following deterministic trend function (DT_t):

$$DT_t = \alpha + \beta DU_t + \delta_0 t + \delta_1 DT^*_t \tag{10}$$

where, α is the intercept, DU_t is the structural change in the intercept, t is the linear trend and DT^*_t is the structural change in the linear trend.

The first alternative allows for a structural change reflected only in the intercept (model AO1 or crash model). The second model only allows for a change in the slope (model AO2 or changing growth model). The third model allows for changes both in the intercept and the slope (model AO3).

The strategy followed by Perron is first to de-trend the series and then analyze the behavior of the residuals taking into account a given structural break point, which is defined ex-ante. For this reason, it is criticized for the possibility of allowing a pre-testing bias.[11]

There have been several attempts to endogenize the structural breaks by using recursive, rolling and sequential tests. The first two take sub-samples, from the general sample, that may grow or remain fixed (with a constant marginal weight for the new data points); meanwhile, the sequential test

[11] One of the most important criticisms results from the fact that this produced a pre-testing bias in favor of the non-rejection of the null hypothesis of a structural break. The condition of independence in the distribution with respect to the data was not satisfied. For this reason, Perron (1994) and Volgelsang and Perron (1994) developed a testing methodology, which allowed for the endogenous detection of the break date. With respect to the use of a priori information, Maddala and Kim (1998) state that this criticism is partially unjustified since it would not make sense to look for a structural break in the whole sample when we know that there is a significant event. According to the authors, the search should be performed around this event.

progressively increases the date of the hypothetical break by using different dummy variables.

The endogeneization of one structural break gave rise to several papers that reverted to previous Perron results, but when the existence of more than one endogenous structural break is allowed, the number of rejections of the UR hypothesis once again increases. Perron (1993, 1994, 1997) and Volgelsang and Perron (1994) propose two models to allow for endogenous structural changes: Additive Outliers (AO) model and Innovational Outliers (IO) model.

The difference between the two models is in the way they understand the structural change. In the AO model the change is abrupt while in the IO change is gradual and is affected by the behavior of the *noise function* since it moves in a similar way to the shocks that affect this function (Cati, 1998).

For AO models the three kinds of structural changes as seen before (models AO1, AO2 and AO3) are applicable while for the IO models only IO1 and IO3 are relevant (the crash model and the model with breaks in both slope and intercept). The IO2 version (changing growth model) in the IO models is not often used in empirical applications because it is not easy to apply when using linear estimation methods.

V. The Methodology

Here we present a procedure to test the order of integration in time series.[12] Our methodology consists in performing the following eleven tests and then making an overall evaluation: (1) Augmented Dickey-Fuller (ADF) test; (2) Phillips-Perron (PP) test; (3) Rolling ADF test; (4) KPSS test; (5) Variance Ratio test (VR, version Campbell, Lo, and MacKinley, 1997); (6-8) Perron's tests with exogenous selection of the break date. Models AO1, AO2 and AO3; (9-11) Perron's tests with endogenous selection of the break date. Models IO1, IO3 and AO2.

The overall evaluation consists of gathering in one matrix the order of integration obtained from the eleven tests and thus evaluating the best

[12] In the application of the methodology we present the technical details concerning the implementation of the tests.

specification of the DGP in each series. It is advisable to use an equiproportional weighting of each result but, of course, sequential analyses or other strategies could be useful depending on the researcher's interest.

VI. Empirical Application to Argentina

As an application of this methodology we analyze the main Argentine macroeconomic variables. Argentina is a country with high volatility and high probability of structural breaks as well as I(2) series. For that reason the data used in this paper has a number of interesting features that will be useful for checking our methodology.

We believe that this is an important contribution, since as far as we know, such an integral analysis does not exist. We have found as an immediate antecedent, though partially related to our work, the important paper by Sosa-Escudero (1997). However, emphasis is placed on the GDP. Additionally the series only reaches the year 1992. Another work, also partially related to ours, is that of Ahumada (1992) on cointegration in nominal variables. Sturzenegger (1989) analyzes the kind of shocks affecting Argentina's GDP using the Blanchard and Quah (1989) decomposition. For more recent sources that include most of the convertibility period (which began in 91:2) Carrera, Féliz and Panigo (1998a, b) present the results for the GDP and inflation in the first paper and for the real exchange rate in the second one.[13]

A. The Data

The data is quarterly (for the period 1980:1 - 1999:4), with the exception of the unemployment rate, the participation rate and employment rate which are semi-annual (for the period 1974:1 - 1999:2).

GDP, investment and trade balance were provided by the Ministry of the Economy and Publics Works, while wages, CPI, participation rate, unemployment rate and employment rate were provided by the INDEC, the Argentine Government's Statistical Office. We used the passive nominal

[13] However, no other paper has followed an integral approach such as the one presented in this paper.

annual interest rate as the proxy for the interest rate with information provided by the Economic Commission for Latin America and the Caribbean (ECLAC). Finally, data on M1 and the nominal exchange rate (used to calculate the real exchange rate) were provided by the Central Bank of Argentina (BCRA). The trade balance is presented as a percentage of GDP.

The data was transformed by seasonally adjusting it using the X-11 ARIMA methodology, except for the semi-annual variables. Then we applied the logarithm function to the series, with the exceptions of the nominal interest rate, the trade balance, M1 growth, inflation and the semi-annual variables which were left unmodified because they are all expressed in percentages. We used the software package RATS 4.2. The real exchange rate was calculated from the nominal exchange rate of the Peso to the American dollar, correcting it by the evolution of Argentina's and US's consumer price index (CPI). We analyzed M1 and M1 growth, as well as the CPI and inflation (CPI growth), separately, because the log approximation of growth for these series is not applicable due to the fact they present strong oscillation in this sample period.

B. Implementation and Results

In this section we apply the methodology proposed in section IV for the macroeconomic variables described above.[14]

The first step is to start with the traditional UR tests. In order to choose the number of lags in the ADF test we followed the "General to Specific" methodology. Beginning with 6 lags, we established for each series the adequate number of lags for the logarithms of the levels as well as for the first differences of the series. The greatest number of lags was used for the GDP and the real wages and the lowest for the real exchange rate. For the Phillips-Perron test (PP) we established a uniform number of lags following the Newey-West (1994) criterion that suggests three lags for a quarterly series. Regarding the structure of both ADF and PP tests we checked in each case the significance of using an intercept (I), an intercept and a trend (I, T) or neither of them

[14] The results for all the tests performed in the paper may be sent by the authors on request.

(NDR). In almost all cases for the first differences we used no deterministic regressors. The critical values used are those from MacKinnon (1991).

Rolling estimation of ADF t statistic was developed taking $\delta_0 = 28$ observations for quarterly data and $\delta_0 = 20$ observations for semiannual data. The stochastic and deterministic regressors for the rolling equation are taken from an ADF test for the entire sample.

We then performed the KPSS test for stationarity as null. For each variable (in levels and first differences) we estimated the LM statistic under two alternative structures for the deterministic component: intercept only and intercept plus linear trend. Maintaining the frequency of the observations for each variable, we included up to four lags for quarterly series and up to two lags for the variables that appear twice a year.

Then we implemented the Variance Ratio Test (VR) for each series taking k = 20 quarters. The critical values and p-values of the null hypothesis of unit root have been constructed from Lo and MacKinlay's (1988) work.

With Perron's Unit Root test with an exogenous structural break we tested the three alternative models presented in section III. Critical values for the tests can be found in Perron (1989). As regards the dates of the breaks, after a qualitative analysis of the series, we decided to use as break date for the GDP and the other real variables the third quarter of 1989 (89:III) since it coincides with the lowest point of most of them and with the coming to power of a new government, that implemented a strong set of policies of structural changes to gain credibility (see Table 3). For the nominal variables, on the other hand, the most relevant structural change seems to have been dated in the second quarter of 1991 (91:II), with the beginning of the Convertibility Plan (Currency Board) that dramatically reduced to international standards the rates of change and the volatility of these variables. With respect to real wages we chose as a structural break the third quarter of 1984 (the last "Keynesian" attempt to increase real wages), since from that date onwards the variable changed its growing trend and began to fall.

Afterwards, we executed Perron's Unit Root test with an endogenous structural break for the IO1, IO2 and AO2 models already described.

In Table 4 we present a comparative analysis for each variable using the eleven test proposed in the methodology. To build a unique indicator of integration, we took the order of integration suggested by each test for each

Table 3. Perron Unit Root Test

Variables	Exogenous selection of SB		Endogenous selection of SB	
	Model	Break date	Model	Break date
GDP	AO1	III/89	IO1	IV/92
	AO2	III/89	IO2	IV/88
	AO3	III/89	AO2	I/89
Nominal wages	AO1	II/91	IO1	II/87
	AO2	II/91	IO2	I/89
	AO3	II/91	AO2	IV/92
Real wages	AO1	III/84	IO1	I/82
	AO2	III/84	IO2	I/82
	AO3	III/84	AO2	III/81
Nom. interest rate	AO1	II/91	IO1	I/89
	AO2	II/91	IO2	IV/89
	AO3	II/91	AO2	III/88
M1	AO1	II/91	IO1	I/88
	AO2	II/91	IO2	IV/88
	AO3	II/91	AO2	III/93
M1 growth	AO1	II/91	IO1	II/89
	AO2	II/91	IO2	II/89
	AO3	II/91	AO2	IV/89
Cons. price index	AO1	II/91	IO1	II/87
	AO2	II/91	IO2	IV/88
	AO3	II/91	AO2	I/93
Inflation	AO1	II/91	IO1	IV/89
	AO2	II/91	IO2	II/89
	AO3	II/91	AO2	I/89
Real exchange rate	AO1	III/89	IO1	I/89
	AO2	III/89	IO2	III/89
	AO3	III/89	AO2	I/83
Trade balance	AO1	III/89	IO1	II/90
	AO2	III/89	IO2	II/90
	AO3	III/89	AO2	III/87

Table 3. (Continued) Perron Unit Root Test

Variables	Exogenous selection of SB Model	Exogenous selection of SB Break date	Endogenous selection of SB Model	Endogenous selection of SB Break date
Investment	AO1	III/89	IO1	I/93
	AO2	III/89	IO2	IV/88
	AO3	III/89	AO2	IV/88
Participation Rate	AO1	I/84	IO1	I/87
	AO2	I/84	IO2	I/82
	AO3	I/84	AO2	II/82
Unemployment rate	AO1	II/91	IO1	I/94
	AO2	II/91	IO2	II/89
	AO3	II/91	AO2	II/89
Employment rate	AO1	I/84	IO1	II/87
	AO2	I/84	IO2	II/87
	AO3	I/84	AO2	II/80

variable and calculated the percentage each type of order of integration in every series.

The results show that GDP, investment and the trade balance are the only three series that pass all the tests, so we can consider them as robustly (or with a great level of confidence) I(1). The assumption of a stochastic trend when proceeding to extract the cycle seems to be the best strategy to accurately model the series. In the case of GDP, our results are similar to those of Sosa-Escudero (1997) for the period 1970-92.

The real exchange rate is a non-stationary variable in the sample as a whole. Only for models AO1 and IO2 the variable is considered stationary at 5%.

The nominal interest rate, M1 growth and inflation are clearly stationary variables. They present an endogenous structural break in 1989 according to the majority of the structural break tests. This indicates that "Convertibility" is not the key date for this series, as we had assumed in the case of exogenous breaks.

Table 4. Comparative Results of the Different Test for the Unit Root Hypothesis

Variables	Econometric test*											Percentage of results		
	A	B	C	D	E	F	G	H	I	J	K			
GDP	1	1	1	1	1	1	1	1	1	1	1	100.0	0.0	0.0
Nominal wages	1	1	1	2	2	1	1	1	1	0	1	72.7	9.1	18.2
Real wages	1	1	1	1	1	1	0	1	1	1	1	90.9	9.1	0.0
Nominal interest rate	1	0	0	0	1	0	0	0	0	0	1	27.3	72.7	0.0
M1	2	1	2	1	2	1	1	1	1	0	1	63.6	9.1	27.3
M1 growth	0	0	0	0	1	0	0	0	0	0	0	9.1	90.9	0.0
CPI	2	1	2	1	2	1	1	1	1	0	1	63.6	9.1	27.3
Inflation	0	0	0	0	1	0	0	0	0	0	1	18.2	81.8	0.0
Real exchange rate	1	1	0	1	1	0	1	1	1	0	1	72.7	27.3	0.0
Trade balance	1	1	1	1	1	1	1	1	1	1	1	100.0	0.0	0.0
Investment	1	1	1	1	1	1	1	1	1	1	1	100.0	0.0	0.0
Participation rate	1	1	1	1	1	1	0	0	1	0	0	63.6	36.4	0.0
Unemployment rate	1	1	0	1	1	1	1	1	0	1	0	72.7	27.3	0.0
Employment rate	1	1	1	0	1	1	1	1	1	1	1	90.9	9.1	0.0

Notes: *Order of integration. The order of integration derived from each test (for each variable) has been selected comparing the observed statistics with the 5% critical value. A: Augmented Dickey-Fuller $t_{\rho=1}$ statistic; B: Philllip-Perron Z_t statistic; C: Rolling $t_{Min\ ADF}$ statistic; D: KPSS-LM statistic; E: Variance ratio statistic; F, G and H: Perron test with exogenous structural break, for AO1, AO2 y AO3 models, respectively; I, J and K: Perron test with endogenous structural break, for IO1, IO2 and AO2 models, respectively.

M1 (in levels), the CPI and nominal wages show a strong non-stationary behavior.[15] For some of the tests these series appeared as I(2). Only the IO2 test, which is the most flexible in allowing for changes, indicated that these three series were I(0) even at 1% with a break date around 88:IV and 89:I where the intercept and the slope changed for the nominal variables in levels.

The series for the labor market have a behavior that tends to be non-stationary. The value for employment and real wages is very close to I(1). Employment is always I(1) except for the KPSS test where it is I(0). The AO2 test, that allows the analyst to select the break date, suggests that real wages are I(0) but only at 5%. It is interesting to observe that none of the tests that allows for the endogenous selection of the break date finds an I(0) result for these variables.

The participation rate and the unemployment rate have intermediate-high values, which indicate the possible presence of a structural break or fractional integration.[16] While the conventional ADF type tests say the series are I(1), the Perron tests with structural breaks partially reject this hypothesis.

VII. Conclusions

The objective of this paper is to provide a useful methodology to analyze the persistence of shocks affecting the macroeconomic series and its consequences on the modeling of cyclical and permanent components. Our strategy is to test the order of integration in time series by using a set of

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[15] Nominal wages is the sole variable that appears to be I(2) in the KPSS test for stationarity as null.

[16] In recent years several econometrists have argued that ARIMA models are far too restrictive and that ARFIMA models (Autoregressive Fractionally Integrated Moving Average) provide an alternative. The autocorrelation function of an ARFIMA process can be shown to decay at a hyperbolic rate for values of d different from zero. This is a much slower rate than the geometric rate associated to stationary ARMA processes. They allow a series to present an ARMA behavior after being differentiated in a fractional manner. Granger and Joyeux (1980) and Hosking (1981) proposed the use of ARFIMA models to model “long memory” processes. In the context of applied econometrics, Sowell (1992b) described how the ARMA component can recover the short run behavior while the fractionally differentiated component recovers the long run behavior.

indicators in such a way that we can analyze the problem from different approaches.

We applied this methodology to the main macroeconomic variables for Argentina. In the case of the most flexible unit root test with a structural change, IO2, 6 out of the 14 variables result I(1) in comparison with the 10 out of 14 for the ADF case. According to its order of integration, the series could be grouped into four groups: (1) The nominal interest rate, M1 growth and inflation appear to be stationary. (2) The real exchange rate, unemployment and participation rates have a greater degree of persistence in shocks, which indicates the possibility of fractional integration. (3) GDP, real wages, trade balance, investment and the employment rate is the group for which most tests appear to be I(1), a confirmation of the unit root hypothesis. (4) Finally, the nominal wages, M1 and the CPI seem to have more than one unit root.

For these last variables in group 4, the results show remarkable differences between the complete sample conventional tests and those that allow for structural change. These variables seem to have changed form I(2) to I(1) in the nineties.

Based on the results of the series in group 3, the best structure for modeling their cycle seems to come from assuming a stochastic trend in the series. The underlying macroeconomic intuition is the idea that shocks affecting these variables have permanent effects. Given the fact the GDP is amongst these, its cycle would be better represented by the first differences of this series (see panel a, Figure 1).

On the other hand, for series in groups 1 and 2 a deterministic trend (with or without a structural break depending on the case) seems to be the most appropriate strategy for calculating the cycle. The kinds of shocks affecting these series are mainly transitory. This implies one of two things: either the economy has forces that automatically regulate it, reverting the deviations of the series from its trend, or the policy actions taken to avoid the persistence of the deviations have been effective.

With respect to variables in group 4, we recommend a thorough analysis, looking for the possibility of multiple structural breaks and/or the correct specification of the time polynomial included in the deterministic component of the tests.

Finally, if we allow for the endogenous selection of the structural breaks, hyperinflation and not the implementation of the Convertibility seems to be the most important structural break in the majority of the series.

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