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UNIT ROOTS IN MACROECONOMIC TIME SERIES: A POST KEYNESIAN INTERPRETATION

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SUMÁRIO

ABSTRACT

The theme of unit roots in macroeconomic time series has received a great amount of theoretical and applied research in the last two decades. This paper focuses on the implications of the existence of unit roots for macroeconomic theorizing. It is argued that the presence of unit roots in GNP time series provide support to the general perspective adopted by Keynes and post Keynesians on output and employment fluctuations, on the non-neutrality of money in the long run, and on some economic policy issues.

JEL Classification: C22: Time-series models – E32: Business Fluctuations; Cycles

RESUMO

A existência de raízes unitárias em séries temporais macroeconômicas tem sido objeto de extensa pesquisa teórica e empírica nas últimas duas décadas. Este artigo enfoca as implicações da existência de raízes unitárias para a teoria macroeconômica. Argumenta-se que a presença de raízes unitárias em séries temporais de PIB representa evidência favorável à perspectiva adotada por Keynes e os pos-Keynesianos no que se refere a flutuações de emprego e produto, à não neutralidade da moeda no longo prazo, e a algumas questões de política econômica.

Classificação JEL: C22: Modelos de series temporais – E32: Flutuações Econômicas; Ciclos

1. INTRODUCTION

The question of whether or not macroeconomic time series present a unit root has been exhaustively discussed within the *mainstream* of economics in the last two decades. The work of Nelson and Plosser (1982) is usually recognized as the starting point of this literature, with significant implications for econometric modeling, for business cycle theorizing, and for economic policy prescriptions.

The presence or absence of unit roots, to put it in a simple way, helps identifying some features of the underlying data-generating process of a series. If a series has no unit roots, it is characterized as stationary, and therefore exhibits mean reversion in that it fluctuates around a constant long run mean. Also, the absence of unit roots implies that the series has a finite variance which does not depend on time (this point is crucial for economic forecasting), and that the effects of shocks dissipate over time.

Alternatively, if the series feature a unit root, they are better characterized as non-stationary processes that have no tendency to return to a long-run deterministic path. Besides, the variance of the series is time-dependent and goes to infinity as time approaches infinity, which results in serious problems for forecasting. Finally, non-stationary series suffer permanent effects from random shocks. As usually denominated in the literature, series with unit roots follow a *random walk*.

In sum, the existence (or not) of unit roots in macroeconomic time series brings about important implications, and this helps to explain why this topic has received a great amount of theoretical and applied research in the last two decades. There are many different issues in the unit roots literature that are somehow related but can be explored separately. To the question "why do we care about unit roots in GNP?" Cribari-Neto (1996, p. 38) provides the following answer:

> "To a policymaker the answer could be: 'Because the policy implications are different.' To a macroeconomist, it could be answered that 'there are theoretical implications on several theories and models.' Finally, an econometrician would be satisfied with the answer: 'Because the asymptotics are different.' "

On the other hand, the presence or absence of unit roots in macroeconomic time series has not received a great deal of attention from post Keynesians, despite the possible implications of unit roots for theory and policy within the post Keynesian paradigm, and despite the importance of this theme in macroeconomics research within the *mainstream*. This paper tries to tackle this question and argues that the presence of unit roots in macroeconomic time series provide support to the general perspective adopted by Keynes and post Keynesians on output and employment fluctuations, on the non-neutrality of money in the long run, and on some economic policy issues. Therefore, this paper agrees with Cross (1993, p. 307) when he says that "tests for unit roots (…) have surely offered insights into the nature of macroeconomic processes which do not entirely conflict with post Keynesian views."

The main focus of this paper will be the implications of unit roots in GNP time series for macroeconomic theorizing. In particular, the paper analyzes how different orthodox theories of macroeconomic fluctuations interpret the findings of unit roots, and it also offers an alternative interpretation, based on the work of Keynes and the post Keynesians. The remainder of the paper is organized as follows. Next section briefly describes the concept of unit roots in time series and the

major unit root test in the literature. Sections 3 and 4 consider the implications of unit roots for *mainstream* business cycle theorizing, including the initial support for real business cycle theories (section 3), and the reactions to that perspective (section 4). In section 5, I present an alternative perspective to the existence of unit roots in GNP time series, based on the post Keynesian theory of output determination. The last section summarizes the arguments and suggests some economic policy implications of the analysis.

2. TESTING FOR UNIT ROOTS IN GNP SERIES

Consider two alternative models used to represent GNP time series:

(1) $y_t = a + bt + e_t$

(2) $y_t = a + y_{t-1} + e_t$

where y_t represents the natural logarithm of GNP at time t, *t* represents a time trend, *b* is a constant that gives the growth rate of the variable, and *e* is an error term with zero mean and finite variance.

The first specification implies that GNP equals the constant *a* at time zero ($y_0 = a$) and grows over time at a constant rate *b*, with the error term explaining deviations from the trend in each year. In other words, the variable y_t presents a stationary fluctuation around the time trend $a + bt$. Therefore, the variable is described as *trend stationary* (TS), and stationarity is achieved by removing the time trend ("detrending"), i.e. regressing y_t on *t*. Another feature of model (1) is that the variance of y_t is bounded by the variance of e_t, and the linear forecast of GNP converges to the time trend $a + bt$ as the forecast horizon increases. Finally, for the first specification, the effects of a shock at time *t* tend to zero over time, since the error term affects the outcome in the current period, but has no persistent influence in succeeding time periods.

Model (2), on the other hand, specifies that GNP grows at rate *a* from its previous value, with an error term playing a role every year. Despite the apparent similitude between the two models, they are indeed very different, and lead to different implications in many respects.

First, model (2) is non-stationary and cannot be made stationary through detrending. But note that the first difference of the series is given by $a + e_t$, a stationary process. So, stationarity can be achieved by differencing, and the model is said *difference stationary* (DS). Model (2) is one of the simplest AR(1) processes, and can be described as a *random walk* with drift. The dependent variable displays a random fluctuation given by the error term e_t, in addition to the growth given by the drift term *a*. Contrarily to model (1), however, there is not any tendency for y_t to return to a predetermined mean value, and its trajectory is given by an accumulation of disturbances. In other words, the error term affects not only what happens in the current period, but also what happens in all succeeding periods. In order to better visualize this point, we can substitute repeatedly for the lagged y_t value in equation (2) to get:

(3) $y_t = y_0 + at + \sum_{i=1}^{t} e_i$

It is straightforward to see that the variance of y_t grows without bound over time, and that shocks to the system (captured by the error term) have a permanent effect on the series. Also, the mean square error of the forecast of the DS model grows linearly with the forecast horizon.
Model (2) represents the *unit root hypothesis*, a terminology arising from the fact that the coefficient on y_{t-1} is unity. If this coefficient was less than unity, the series would be stationary (mean reverting) and random shocks would dissipate over time.[1]

In sum, the two models are indeed different and have different implications. Therefore, it became common practice to check whether a GNP series can be better described as a TS or a DS process. This is usually done by testing for the presence of a unit root in the autoregressive representation of the series. If a unit root is found, traditional estimation techniques cannot be used since, as is well known, spurious results are obtained when two variables with unit roots are regressed on each other: misleadingly high R squares and t statistics, and very low DW statistics.

There are different ways to test for the presence of unit roots. According to Elder and Kennedy (2001, p. 138), "the augmented Dickey-Fuller (ADF) test has become the most popular of many competing tests in the literature." It consists in estimating by OLS a model such as

(4) $y_t = a + bt + u.\, y_{t-1} + e_t$ in the form

(5) $\Delta y_t = (u - 1).\, y_{t-1} + a + bt + e_t$

and then testing for $u=1$ (null hypothesis of unit root) using a t test[2]. Failing to reject the null is equivalent to failing to reject the existence of a unit root or stochastic trend in the data series.

Two major issues in performing ADF tests are the inclusion (or not) of an intercept term, a trend term, or both, and the selection of the truncation lag. ADF test results are very responsive to the presence of intercept and trend terms, and to the number of lags included. In general, including too many deterministic regressors results in lost power, whereas not including enough of them increases the probability of not rejecting the unit-root null.[3]

3. UNIT ROOTS AS A SUPPORT TO REAL BUSINESS CYCLE THEORY

The work of Nelson and Plosser (1982) is usually considered the starting point of a vast amount of research on unit roots in macroeconomic time series. Their paper uses long historical time series of annual data for 14 variables for the U.S. economy, including measures of output, employment, prices, wages, money stock, and interest rates. Starting dates range from 1860 to 1909, and all series end in 1970. Nelson and Plosser's goal is to examine whether these time series are better characterized as TS or as DS processes.

[1] The macroeconomic implications of unit roots will be addressed in more detail in the following sections.

[2] Note that under the null hypothesis this t statistic is not asymptotically normally distributed, and therefore special critical values are required. Actually, critical values depend on the regression specification and on the sample size. Dickey and Fuller (1979), among others, provide tables with appropriate critical values for some cases.

[3] A complete description of unit root tests is beyond the scope of this article. For a more detailed explanation, see Enders (1995), chapter 4.

In particular, they intend to question the traditional practice of decomposing output series into a secular component (long run deterministic trend) and a cyclical component (stationary short run fluctuations around trend). Nelson and Plosser argue that, if the series is non-stationary (i.e. features a unit root in its autoregressive representation), then the secular component should be modeled as a stochastic process, responsible for any long run non-stationarity observed in the series, since the cyclical component is assumed to be transitory. In other words,

> "Since cyclical fluctuations are assumed to dissipate over time, any long-run or permanent movement (non-stationarity) is necessarily attributed to the secular component." (Nelson and Plosser, 1982, pp. 139-40)

In this case, aggregate output is thought of as consisting of a non-stationary growth component plus a stationary cyclical component, being the total variation in output changes attributed to both components.

Nelson and Plosser (1982) then analyze sample autocorrelations and test for the existence of unit roots in the fourteen long run time series, and find that the null hypothesis of a unit root cannot be rejected at 5% for most of the series. Nelson and Plosser acknowledge that non-rejection of the null hypothesis does not necessarily imply that the null is 'true'. This is particularly important in the case of unit root tests, since such tests usually have low power, *i.e.* cannot differentiate between unit roots and a TS alternative with an AR root arbitrarily close to unity. However, they argue, if the deviations from a linear trend in the series are stationary, "*then the tendency to return to the trend line must be so weak as to avoid detection even in samples as long as sixty years to over a century*." (Nelson and Plosser, 1982, p. 152)

To sum up, Nelson and Plosser conclude that the evidence presented support the DS representation of non-stationarity in economic time series, and that in this case economic fluctuations are better explained by movements in the secular component (caused mainly by real factors, such as changes in tastes and technology) than by the cyclical component.

In other words, the evidence of unit roots in GDP time series was interpreted by Nelson and Plosser (1982) as providing support for theories of fluctuations based on real (as opposed to monetary) factors. This argument has strongly influenced the direction of *mainstream* macroeconomic research since the 1980s[4]. Some authors argue that the advance of Real Business Cycle (RBC) models – full equilibrium models with emphasis in technology shocks as source of fluctuations – is mainly due to the empirical findings of Nelson and Plosser (1982). According to McCallum (2000, p. 119), "the logical basis for the upsurge of the RBC movement can be viewed as principally empirical." Or, as stated by Backhouse and Salanti (2000, p. 12),

> "Although decisive tests are rarely possible, some papers cite one example where such a test occurred: the rejection of the hypothesis that monetary shocks were the cause of the business cycle. This led directly to the emergence of real business cycle theory."

[4] The main effect can be seen as the advance of real business cycle models and the decline of new classical models – developed by Lucas, Sargent, and Barro, among others, during the 1970s – in which monetary misperceptions were considered the major source of output fluctuations.

The argument used by Nelson and Plosser (1982) is that most of the fluctuations in output should be attributable to changes in the trend component, in a trend versus cyclical decomposition, which would presumably be unaffected by monetary factors. In other words, the existence of unit roots leads to the inference that movements in output are persistent; since the cyclical component is *assumed* to be stationary, it follows that output fluctuations are mostly associated with the secular component. The argument is completed by the idea that monetary shocks are necessarily temporary and so can only affect the cyclical component, and that the long run path of the economy is mainly guided by real factors such as tastes and technology.

Nelson and Plosser's main conclusion in terms of macroeconomic theorizing follows directly from such reasoning, and can be summarized as:

> "We conclude that macroeconomic models that focus on monetary disturbances as a source of purely transitory (stationary) fluctuations may never be successful in explaining a very large fraction of output fluctuations and that stochastic variation due to real factors is an essential element of any model of economic fluctuations." (Nelson and Plosser, 1982, p. 141)

It is worthy to note that the argument rests on a number of implicit or explicit building blocks, all of them necessary for the final conclusions. First, Nelson and Plosser use the evidence of unit roots in GNP time series, although they recognize that none of the tests used can distinguish conclusively between a difference stationary process and a trend stationary process with an autoregressive root arbitrarily close to unity.

Second, it is inferred that innovations in the stochastic trend component have a larger variance than the innovations in the transitory component, and this leads to the conclusion that variations in the cyclical component of fluctuations are small in comparison with fluctuations in the trend component. Note that this inference is dependent upon the ability of the empirical analysis to differentiate between a DS and a TS process.

Third, the classical dichotomy between real and monetary variables is assumed. In particular, it is assumed that the cyclical component is stationary, and mainly affected by monetary factors, which are neutral in the long run[5]. In this respect, Nelson and Plosser acknowledge in a footnote that the theoretical possibility of a "Tobin effect" of sustained inflation on the steady-state capital stock is ignored in their analysis. It is clear that once money is allowed to play any significant role in the long run path of the economy, unit roots do not necessarily support RBC theories (I will return to this point later). In addition, concerning the stationarity of the cyclical component, Nelson and Plosser admit it is a proposition that cannot be inferred from empirical analysis. However, they justify its use by saying that it is an assumption "we believe most economists would accept." (Nelson and Plosser, 1982, p. 160)

The macroeconomic implications of the work of Nelson and Plosser (1982) are controversial, and have not gone uncontested. Many arguments in different directions have been developed in opposition of Nelson and Plosser's findings. In very general terms, two interrelated lines of criticism

[5] Indeed, Nelson and Plosser seem to consider a direct and unequivocal association between aggregate demand, monetary factors, and stationary cycles, on one hand, and aggregate supply, real factors, and stochastic trend components, on the other.

can be identified in the *mainstream* literature. The first one relates to an effort to reconcile the presence of unit roots in GNP time series with theories of output fluctuations other than RBC models; the other one contests the very existence of unit roots in the series or, more precisely, stress the inability of unit root tests to differentiate between TS and DS processes in data covering limited time spans[6].

4. UNIT ROOTS AND NEW KEYNESIAN ECONOMICS

The first reactions to the conclusions of Nelson and Plosser can be seen as an attempt to promote new Keynesian models of aggregate fluctuations, in which GNP is expected to revert to a long run trend, but in which the adjustment process can be very slow due to imperfections in goods and labor markets. A number of papers were published during the 1980s with different arguments in this direction.

McCallum (1986) claims that the statistical evidence provided by Nelson and Plosser cannot be interpreted as providing support for RBC theory, since this evidence is equally consistent with other theories of business cycle. His criticism is primarily devoted to the second "building block" mentioned before, i.e. that the cyclical component of fluctuations has little importance relative to the secular component.

According to McCallum (1986) this point cannot be inferred from the data presented by Nelson and Plosser (1982), because it depends on the hypothesis that GNP series follows a DS process, which in turn is not guaranteed. McCallum points out and evaluates three types of evidence presented by Nelson and Plosser in favor of the hypothesis of non-stationarity. The first evidence is that the sample autocorrelations for annual GNP data are large and decay slowly. The second evidence is that the autocorrelations of annual GNP differences are positive and significant at lag one, but often not significant at longer lags. McCallum shows that both evidences are also compatible with the behavior of a trend stationary series with a root close to one, and concludes that it is not possible to determine with any degree of certainty if a series is difference stationary or trend stationary simply by inspection of the autocorrelation functions for levels and differences. The third evidence provided by Nelson and Plosser (1982) is formal tests of unit roots. Also in this case, McCallum argues, the evidence is far from conclusive, since unit root tests have low power to distinguish between a DS process and a TS process with an AR root close to unity.

In addition, McCallum (1986) shows that if the decomposition of the series into cyclical and secular components assumes that the latter is given by a DS process when the process under study is actually one of the TS class with an AR root close to one, then it follows that the variability of the cyclical component will be underestimated. He concludes that

[6] Other reactions to the work of Nelson and Plosser relate to the discussion of alternative procedures for performing unit root tests. In this case, one of the most important contributions is the work of Perron (1989), which considers the presence of exogenous structural breaks in the series, and allows for a differentiation between "small" and "large" shocks. This and other developments in econometric modeling are beyond the scope of this article.

> "The time series evidence provided by Nelson and Plosser (1982) is inadequate to determine whether the relevant series are of the DS or TS class. This evidence itself, then, sheds little or no light on the issue of the relative variability of cyclical and secular components of typical macroeconomic time series – and consequently provides little or no support for the RBC hypothesis." (McCallum, 1986, p. 407)

The work of Campbell and Mankiw (1987) is also motivated by the findings of Nelson and Plosser (1982). Campbell and Mankiw assert that their goal is to question the view that economic fluctuations can be seen as temporary deviations from a deterministic trend. In view of that, their starting point is the assumption that if output series are stationary and therefore mean-reverting, then a current shock should not change one's forecast of output in the long run (say, five to ten years). Campbell and Mankiw (1987) provide evidence of unit roots in postwar GNP time series, and suggest that persistence of shocks is an important aspect of the data, which "should be used more widely for evaluating theories of economic fluctuations." (Campbell and Mankiw, 1987, p. 858) However, they do not agree with the idea that the existence of unit roots is clear evidence that real, supply-side shocks are the main cause of the business cycle, or that fluctuations based on aggregate demand disturbances should be abandoned.

According to Campbell and Mankiw (1987), traditional theories of economic fluctuations accept two basic premises: (i) fluctuations are mainly caused by aggregate demand shocks; (ii) demand shocks have only short-term effects, and the economy reverts to the natural rate of output in the long run. They argue that Nelson and Plosser's "extreme" (p. 876) conclusions follow from the abandonment of the first premise. Alternatively, they suggest that another way to cope with persistence of shocks is to abandon the second premise, the natural rate hypothesis. This would open the possibility of aggregate demand shocks having persistent effects on output, and this result could be explored in models of multiple equilibria. Campbell and Mankiw conclude:

> "Perhaps models of temporary nominal rigidities (e.g., Fischer [1977]) or misperceptions (e.g., Lucas [1973]) could be reconciled with findings of persistence by abandoning the natural rate hypothesis in favor of some highly potent propagation mechanism." (Campbell and Mankiw, 1987, p. 877)

In sum, Campbell and Mankiw seem to provide a response to the work of Nelson and Plosser (1982). In other words, they point to the validity of some of the main aspects of "traditional theories of business cycle" despite the findings of Nelson and Plosser. However, it is not clear how models such as Lucas (1973) and Fischer (1977) could survive without the natural rate hypothesis, and Campbell and Mankiw do not present any other suggestions in this direction. In order to reconcile such models with the finding that shocks are persistent, some sort of equilibrium rate of output would possibly need to be assumed in the long run, even if the process of return to trend is assumed to be very slow due to rigidities and other forms of imperfections (like in many models in the new Keynesian literature). This means that the idea of a long-run natural rate of output would ultimately be maintained.

West (1988) offers an answer to this issue, contesting the evidence of unit roots in GNP time series, as well as the necessity to abandon the idea of a natural rate of output. West's argument has two

parts. The first part is the well-known fact that unit root tests cannot discriminate between random walk and near random walk behavior in finite samples. This implies, according to West (1988) that simple analysis of a single-country GNP data series is not sufficient to distinguish between stationarity and non stationarity, and to evaluate the relative importance of nominal and real shocks; therefore, this type of empirical evidence is not sufficient to assert the usefulness of different theories of business cycle.

The second part of West's argument consists in showing that simple natural rate models in which nominal shocks are the main cause of fluctuations can generate results similar to a near random walk in GDP. In short, West (1988) builds a simple model with overlapping wage contracts in which monetary policy is the only source of disturbances. Intuitively, the wage contracts provide an endogenous source of persistence, since prices do not move instantaneously, and GNP fluctuations mimic a near random walk behavior after a monetary policy shock. This is valid even if there is a long run natural rate of output to which the economy eventually converges; all is needed for the near random walk behavior is a very slow process of adjustment. In sum, West's main point is that

> "Neither stationarity of the natural rate nor nominal shocks playing an important role in the business cycle are inconsistent with a root *very near to unity* being present in the GNP process." (West, 1988, p. 207, emphasis added)

It is clear that West minimizes the importance of unit roots in GNP series, based on the fact that random walk and near random walk behavior cannot be distinguished. However, if the *actual* process behind GNP series is difference stationary (although one cannot be sure of it), the concept of the natural rate of unemployment is called into question. Moreover, if the idea of near random walk is a valid description of the behavior of GNP or, in other words, if GNP is trend reverting but with a high degree of persistence, it seems that the concept of a natural rate unique and stable is not very useful anyway[7]. The target is still there, but the economy never reaches it, and successive shocks may drive economic fluctuations independently of what the natural rate is, since its attraction power is very low[8].

5. UNIT ROOTS AND POST KEYNESIAN ECONOMICS

The existence of unit roots in GDP time series and the consequent persistence of shocks can also be used to support different non-mainstream views of economic fluctuations and economic growth, which emphasize the existence of multiple equilibria with the possibility of persistent involuntary unemployment, due to path dependence, hysteresis in labor markets, and non-neutrality of money in the long run, among other considerations.

[7] For a broad discussion of the concept of the natural rate of unemployment, see Cross (1995).

[8] Another line of argumentation in the unit roots debate – known as the "we don't know, and we don't care" argument – claims that it is not really important for macroeconomic theorizing whether or not unit roots are detected in GNP time series. This branch of the literature has a lot in common with some arguments presented in this section, especially those by McCallum (1986) and West (1988), about the inability of unit root tests to distinguish between TS and DS processes in finite samples. In this case, however, the criticism seems to be even more profound; moreover, there is not a defense about any specific theories of economic fluctuations. See Christiano and Eichenbaum (1990), Rudebusch (1992), Diebold and Rudebusch (1999).

In general terms, it can be argued that many theories in which aggregate demand influences the long run equilibrium of the economy, or in which the concept of a natural rate of unemployment (unique and stable) is discarded, are compatible with the presence of unit roots in GNP. Examples include the type of multiple equilibria models developed by Hahn and Solow (1995), structuralist models *a la* Taylor (1991), and the Keynes-post Keynesian approach to macroeconomics, which is the focus of this paper.

The main question our analysis is concerned with is: how to reinterpret the findings of Nelson and Plosser (1982), i.e. the existence of unit roots in GNP time series, in light of post Keynesian ideas? In other words, how would their conclusions change if some of their main theoretical assumptions were abandoned?

It is important to remind a few essential assumptions of the work of Nelson and Plosser (1982), or RBC models in general: (i) cyclical fluctuations in the short run are stationary and mainly affected by aggregate demand disturbances; (ii) money is neutral, and only supply-side shocks (especially technological shocks) affect the long-run path of the economy; (iii) the classical dichotomy between real and monetary variables is valid; (iv) the economy is composed of fully rational agents maximizing an objective function over time, and fluctuations (caused by real shocks) are changes in the full (optimal) equilibrium position of the economy.

A post Keynesian response to Nelson and Plosser's interpretation would not follow the same strategy pursued by New Keynesians and other mainstream macroeconomists, based mainly on a critique of the empirical results (as described in the previous section). Instead, it would consider a different set of assumptions and entail a completely different perspective on how actual monetary economies work. In this case, the question is: how do we interpret the proposition that GNP time series are non-stationary (and what implications can be derived) without the assumptions (i-iv) described above?

The properties of unit-root (non-stationary) series are well known and were briefly described in a previous section of this paper. These properties are interrelated, but I will enunciate them in three separate propositions for analytical convenience. First: non-stationary processes have no tendency to return to a long-run deterministic path, and the trajectory of the dependent variable is given by an accumulation of disturbances. Second: shocks to the system are persistent, and alter the trajectory of the variable in the short and long periods. Third: it is not possible to make accurate predictions about the future behavior of the variable, since the variance of the series is time-dependent and approaches infinity as the forecast horizon increases. All these features were taken by Nelson and Plosser (1982) as a support to RBC models, but they are also entirely compatible with a post Keynesian view of how the real world works.

First of all, under the post Keynesian paradigm, it is recognized that actual capitalist economies function in historical time, i.e. economic events take place in a unidirectional sequence rather than instantaneously ("time is a device that prevents everything from happening at once"), and this implies that the timing and ordering of such events affect the nature of final economic outcomes. In other words, instead of considering an economic system which adjusts inevitably towards some determinate equilibrium, Keynes and the post Keynesians take into account the idea that no equilibrium position can be independent of the trajectory of the economy towards it: history matters!

Moreover, some post Keynesians explicitly discard the (neo) classical axiom of an ergodic economic environment, and emphasize that actual economic processes are non-ergodic (Davidson, 1994). It is clear that non-stationary systems are non-ergodic, since nonergodicity implies that averages calculated from past observations may persistently differ from averages of future outcomes. As Davidson (1991, p. 132n) recognizes it: "Nonstationarity is a sufficient, but not a necessary condition, for nonergodicity." Once again, time series with unit roots represent non-stationary processes and are, therefore, supportive of post Keynesian views of economic processes.

Another important aspect of post Keynesian economics is the emphasis on the uncertainty that surrounds decision-making in a non-ergodic environment. Since economic agents take production and investment decisions based on expectations about an uncertain future, disappointment of expectations or changes in the environment may lead to sudden revisions of such decisions, which affect total expenditures and therefore alter the path of the economy, defining new equilibrium positions. As Davidson (1993, p. 313n) puts it: "the existence of uncertainty, *by definition*, assures that there never need exist a long-run statistical average about which the system will fluctuate as it moves from the present to an uncertain future."

The role of expectations and the possibility of multiple equilibrium positions with involuntary unemployment are clearly described in the post Keynesian literature. It is well known that Keynes used different assumptions about short run and long run expectations and their interaction. The so-called model of shifting equilibrium is considered to be Keynes's "complete dynamic model" (Kregel, 1976, p. 215), and seems to provide the most accurate description of Keynes's views on the nature of decision-making under uncertainty. In this model, short-period expectations may be disappointed and hence change, and such changes also affect long-period expectations[9]. The revision of long-term expectations given current outcomes implies, in turn, that the underlying determinants of aggregate demand (or, the fundamental psychological variables: the propensity to consume, liquidity preference, and the marginal efficiency of capital) are endogenous to the path of the economy. In this case, the long-run equilibrium will itself respond to short-run outcomes, and one should not expect the economy to converge to any predetermined path. According to Kregel (1976, p.217),

> "if (…) realization of errors alters the state of expectations and shifts the independent behavioral functions, Keynes's model of shifting equilibrium will describe an actual path of the economy over time chasing an ever changing equilibrium – it need never catch it."

On the other hand, persistence of shocks is a natural implication of post Keynesian models, and it does not come as a surprise. Moreover, once the assumption of money neutrality is discarded, and the interdependence of real and monetary sectors is considered, the claim that real (technology) shocks are the only responsible for fluctuations in the long run does not make any sense. In the real world, money matters in the short and long run, and nonstationarity may be related to changes in monetary or real variables, and the consequent revision of expectations by economic agents[10].

[9] For formalizations of Keynes's shifting equilibrium model, see Dutt (1997) and Setterfield (1999). In both cases, the models provide several features which are compatible with non-stationary systems, such as path-dependence and no automatic adjustment to a given mean.

[10] Note that "external" shocks are not a necessary condition for economic fluctuations. In the post Keynesian literature, there are many well-known attempts to explain fluctuations and instability that are endogenous to the system (e.g. Minsky's financial instability hypothesis; Minsky [1986]). Also, money is considered to be endogenous, and therefore the idea of a "monetary shock" cannot be directly transferred without some adaptation.

Concerning economic forecasting, the features of non-stationary series are also compatible with post Keynesian perspectives. It is clear that the concepts of nonergodicity and uncertainty imply that the future is not statistically calculable from past data. Keynes emphasized the fact that in many economic processes there is "no scientific basis" for developing accurate inferences about the future: "We simply don't know" (Keynes, 1937, p.214).

6. CONCLUDING REMARKS

This paper discussed the existence of unit roots in macroeconomic time series, and presented different interpretations for the idea that GNP series are non-stationary. The finding of unit roots in GNP was initially used to support real business cycles models, stressing the role of real (technological) shocks in aggregate fluctuations (Nelson and Plosser, 1982). This understanding has been contested by a number of authors, who argued that the empirical analysis of GNP time series was not conclusive and could equally support business cycle theories in which imperfections or rigidities imply a delayed adjustment process towards the natural rate of unemployment (e.g. New Keynesian economics).

This paper follows a different path and offers an alternative interpretation based on the work of Keynes and the post Keynesians. Instead of contesting the validity of Nelson and Plosser's empirical findings, the paper argues that these findings should be interpreted under different assumptions and that GNP time series with unit roots are compatible with the post Keynesian perspective on economic fluctuations. In this case, some important elements are: (i) path dependence and time irreversibility; (ii) multiple equilibria and the absence of a predetermined mean toward which the system converges; (iii) persistence of shocks and non-neutrality of money in the long run; (iv) uncertainty and the inability to have accurate predictions about the future behavior of the variables.

I conclude by briefly mentioning some economic policy implications of the analysis. In general, GNP nonstationarity may lead to the defense of active macroeconomic policies for a number of reasons. First, if the system is not mean reverting and persistent under employment equilibrium is possible, then active monetary and fiscal policies may be needed to improve the performance of the economy, changing its path toward higher levels of output and employment[11]. Second, if the system follows a *random walk*[12], then "Big Government" and "Lender of Last Resort" (Minsky, 1986) may have a role to perform in providing floors and ceilings to constrain economic fluctuations. Third, macroeconomic policies also contribute to reduce uncertainty regarding future prospects of the economy and, therefore, promote faster recovery of investment and output levels after economic contractions.

On the other hand, if there is a unit root in GNP, it is also possible to make a case against sharp contractions as a response to financial or currency crises in emerging economies, as is usually implicit in the recommendations of the IMF and other international financial institutions (Dutt and Ros, 2003). In this case, the negative effects of such policies do not tend to dissipate in the short run, and may even aggravate some of the problems they were supposed to alleviate.

[11] In this case, propositions denying the necessity, desirability, and effectiveness of macroeconomic policies, such as the ones defended by Lucas, Barro and other New Classical proponents are not valid.

[12] According to Cribari-Neto (1996, p. 40) random walks "can take you anywhere".

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