Non-stationarity Tests in Macroeconomic Time Series

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Summary. This paper presents a selective survey of the literature on non-stationarity tests, namely standard and efficient unit root tests and stationarity tests, with or without structural changes. We also present the direct relation between non-stationarity tests and four economic theories, such as business cycles, hysteresis, purchasing power parity and convergence.

Key words: Unit root tests, Stationarity tests, Breaks, Business cycles, Hysteresis, Purchasing power parity, Convergence.

JEL Classification: C12, C22

1 Introduction

Since the influential paper of Nelson and Plosser [99], much attention has been devoted to studying the non-stationarity of macroeconomic time series. The literature observes two types of non-stationary processes: (i) trend-stationary [TS] processes (or processes that are stationary around a trend) where non-stationarity is deterministic, and (ii) difference-stationary [DS] processes (or processes that are stationary in first-differences) where non-stationarity is stochastic (presence of unit roots). In the existence of a unit root, the underlying trend is stochastic, which implies that the series has a long memory, and shocks have persistent effects. As a result, the series does not return to its former path following a random disturbance, and the level of the series shifts permanently. On the other hand, if the series does not contain a unit root, the underlying trend is deterministic and the series has a short memory. In this case, a shock has no permanent impact and the series returns to its steady trend after the shock.

The distinction between the two classes of non-stationary processes is important from the viewpoint of statistical inference because stationarity is achieved from different methods: by removing a time trend (*detrending*, i.e. regressing on time trend)

for a TS process and by differencing for a DS process. There have been several studies that have investigated the effects that arise when stationarity is achieved from inappropriate method (Chan et al. [34]; Nelson and Kang [97, 98]). If the time series is DS and we treat it as TS, this is a case of under-differencing and implies the creation of short cyclical movements and, inversely, we have a case of over-differencing[3] and creation of long cyclical movements. These two forms of non-stationarity have radically different implications for forecasting time series: forecast-error variances grow linearly in the forecast horizon for the DS process, but are bounded for the TS process (Clements and Hendry [38]).

As suggested by Stock [145], there are four main areas for testing univariate non-stationarity in economic time series: (1) data description; (2) medium- and long-term forecasting; (3) a guide for subsequent multivariate modelling; and (4) information on the degree of persistence in a time series and, in particular, on its order of integration can help to guide the construction or testing of economic theories. Here we focus on the fourth area by establishing the direct relation between non-stationarity tests and some economic theories such as business cycles, hysteresis, purchasing power parity and convergence.

The nature of the trend or the non-stationarity (deterministic or stochastic) is generally studied from the unit root tests[4]. Following the seminal work of Fuller [57] and Dickey and Fuller [43], numerous procedures have been developed for testing the hypothesis that a univariate time series contains a unit root against the alternative hypothesis that it is level or trend stationary, called "*standard unit root tests*". However, the power of these unit root tests has been questioned. Evidence has been provided indicating that these unit root tests have size distorsions and low power against meaningful stationary alternatives. Therefore, some useful modifications of these tests have been suggested to solve these problems. Moreover, these standard unit root tests have a common feature of including a constant and/or a deterministic trend in their test regression. However, some studies showed that elimination of deterministic components may bring an efficiency gain to the unit root tests, and this type of tests is called "*efficient unit root tests*". Nevertheless, the tests mentioned above are all based on the null hypothesis of a unit root, which assures that the hypothesis will be accepted (at conventional significance level of 5%) unless there is strong evidence against it. As a result, "*stationarity tests*" have been proposed for which the null hypothesis is level or trend stationary against the unit root alternative. Besides, some studies have shown that the presence of breaks in the time series can also bias the unit root and stationarity tests. Therefore, some tests taking into account structural breaks have been developed: "*unit root tests with structural changes*" and "*stationarity tests with structural changes*".

The outline of the paper is as follows. In Section 2, we briefly describe the different types of non-stationarity tests as mentioned above. The direct relation between

[3]There has been some debate in the literature on the over-differencing versus under-differencing issue, arguing that the former is a less serious error than the latter.

[4]This paper focus only on univariate time series.