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Unit root modeling for trending stock market series

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Abstract

In this paper, we examine how the unit root for stock market series should be modeled. We employ the Narayan and Liu (2015) trend GARCH-based unit root and its variants in order to more carefully capture the inherent statistical behavior of the series. We utilize daily, weekly and monthly data covering nineteen countries across the regions of America, Asia and Europe. We find that the nature of data frequency matters for unit root testing when dealing with stock market data. Our evidence also suggests that stock market data is better modeled in the presence of structural breaks, conditional heteroscedasticity and time trend.

JEL classification: C12; C58; F30; G15

Keywords: Trend; Structural break; Conditional heteroscedasticity; Unit root; Stock market

1. Introduction

The analysis of integration properties of economic series is not new in the literature. Several attempts have been made to characterize the statistical properties of most of the series we engage in empirical analysis. This concept is considered crucial both from statistical and policy perspectives. First, most time series models and techniques require pre-testing the underlying series for unit root. For instance, modeling and forecasting with univariate models such as the Autoregressive Moving Average (ARMA) process relies on stationarity of the series under examination and therefore pre-testing such series with unit root becomes inevitable. Secondly, the impact of shocks can as well be assessed based on the outcome of unit root testing. If a series exhibits unit root, shocks to such series will have permanent effects. However, if it is stationary, then the impact of shocks will be transient. Thirdly, the response of series to shocks has implications for the effectiveness of any policy adjustments. For instance, if a series contains a unit root, policies designed to alter the natural path of the series will be effective because such policies will push the series away from its long-run trend path in the absence of such policies (See also Smyth, 2013; Lean & Smyth, 2013).

Evidently, different economic series have been considered in the literature on unit root testing. Prominent among these series are the real exchange rates [see for example, in the last decade or so, Narayan & Narayan, 2007 (covering Italy); Cushman & Michael, 2011 (OECD Countries); Matsuki & Sugimoto, 2013 (Asia); and El Montasser, Fry, & Apergis, 2016 (US-China)]; Purchasing Power Parity [see Darné & Hoarau, 2008 (focusing on Australia); Hung & Weng, 2011 (Central Asia); Su, Liu, Zhu, & Lee, 2012 (OPEC Countries); Wu & Lin, 2011 (European Union); Liu, Zhang & Chang, 2012 (Transition economies); Yilanci, 2012 (Central and Eastern Europe); Cuestas & Regis, 2013 (OECD

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Countries); Bahmani-Oskooee, Chang, & Lee, 2016 (Africa); and Zerihun & Breitenbach, 2016 (South African Development Community)]; and Real interest rate parity hypothesis [see Güney & Hasanov, 2014 (Post-Soviet Countries); Fu, Li, & Ma, 2015 (Asia); and Güney, Telatar, & Hasanov, 2015 (Transition economies]. Other variables include Energy consumption [see Lean & Smyth, 2014 (Malaysia); Mishra & Smyth, 2014 (US); Shahbaz, Khraief, Mahalik, & Zaman, 2014; Ozturk & Aslan, 2015 (OECD Countries) and Zhu & Guo, 2016]; Inflation rate [see Basher & Westerlund, 2008; Romero-Ávila & Usabiaga, 2009 (OECD Countries); Huang, Lin, & Yeh, 2010 (US); Narayan & Popp, 2011 (G7 Countries); and Yıldırım, Özdemir, & Doğan, 2013 (OECD Countries)]; Income [see Jewell, Lee, Tieslau, & Strazicich, 2003 (OECD Countries); Smyth & Inder, 2004 (China); Beechey & Österholm, 2008 (US); Dawson & Strazicich, 2010 (OECD and Non-OECD Countries); and Solarin & Anoruo, 2015 (Africa)]; and Stock indices [see Tabak, 2007 (Brazil); Narayan, 2008 (G7 Countries); Hasanov, 2009; Gozbasi, Kucukkaplan, & Nazlioglu, 2014 (Turkey); and Tiwari & Kyophilavong, 2014 (BRICS)]. A few others that have received very little attention include CO2 emissions [see Lee, Chang, & Chen, 2008 (OECD countries); Tiwari, Kyophilavong, & Albulescu, 2016 (Sub-Saharan Africa)]; Health expenditure [see Jewell et al., 2003 (OECD Countries); Payne, Anderson, Lee, & Cho, 2015 (OECD Countries]; House prices [see Yang & Wang, 2012 (Sweden); Lean & Smyth, 2014 (Malaysia); Chang, Wu, & Gupta, 2015 (South Africa)]; and Unemployment [Lee, Hu, Li, & Tsong, 2013 (OECD Countries); Bakas & Papapetrou, 2014 (Greece)].

This growing literature on unit root testing has offered different dimensions for verifying the underlying statistical properties of time series. Although, the application of the Augmented Dickey Fuller [ADF]-type unit root tests has remained prominent in the literature regardless of the data frequency; however, when dealing with high frequency series such as daily, weekly and monthly data types, the white noise error assumed in the ADF-type may not be appropriate. There are increasing evidences suggesting that high frequency series such as oil price, stock price, inflation, exchange rate, commodity prices, among others, tend to exhibit conditional heteroscedasticity in addition to their random walk behavior. This observation was first conceptualized and analytically documented by Kim and Schmidt (1993) and thereafter examined by Ling and Li (1998), Seo (1999), Ling, Li, and McAleer (2003) and Cook (2008). Classified as Generalized Autoregressive Conditional Heteroscedasticity [GARCH]-based unit root tests, the tests allow for a GARCH process in the test regression unlike the white noise error assumed in the ADF-type unit root tests. Cook (2008), following Kim and Schmidt (1993) and Haldrup (1994), notes that when error in the ADF-type test regression follows a GARCH process and is ignored, the test is subject to typically moderate size distortion.

Notwithstanding, the earlier versions of the GARCH-based unit root test of Kim and Schmidt (1993) and others are not without their shortcomings. These versions do not account for structural breaks which seem to be a prominent feature of high frequency series. Thus, using these tests in the presence of significant structural breaks may render the statistical inference invalid. In a recent paper by Narayan and Liu [NL thereafter] (2011), the GARCH-based unit root was extended to include two exogenous structural breaks and thereafter, Narayan, Liu, and Westerlund [NLW] (2016) modified the latter to allow for two endogenously determined structural breaks based on the procedure of Narayan and Popp (2010). These tests with structural breaks are found to have better size and power properties than those without structural breaks.

An extension of the NL (2011) and NLW (2016) was also proposed by NL (2015) wherein a time trend was suggested in the test regression. For robustness, the performance of the trend GARCH-based unit root test was compared with others including the NL (2011) and NLW (2016) tests and they find that the trend based test outperforms other GARCH-based tests regardless of whether the break dates are chosen exogenously or endogenously. They conclude that as long as a time trend is included, the manner in which structural breaks is chosen does not make the test unstable. In other words, whether the breaks are selected exogenously or endogenously, in so far a time trend is included in the test regression, the outcome is stable and correctly sized.

It is important to emphasize here that there are several ADF-type unit root tests including the NP (2010) test that also account for both structural breaks and time trend in the test regressions; however, they do not allow for conditional heteroscedasticity.

Motivated by these attractions, we subject the NL (2015) test to empirical scrutiny using the global stock markets covering both the developed and emerging financial markets. The choice of global stock markets [particularly the selected financial markets] is deliberate for a number of reasons. First, there are substantial evidences suggesting that the global stock markets are highly volatile [i.e. they exhibit conditional heteroscedasticity] and have as well witnessed several structural shifts in response to shocks [see Diebold & Yilmaz, 2009]. Our preliminary analyses [see Section 3.0 of our paper] are clear indications of the inherent conditional heteroscedasticity and structural breaks in global stock markets. Secondly, as presented under descriptive statistics, all the series are trending and in fact the trend coefficients for the selected series are all statistically significant. These underlying statistical features of the global stock markets seem to agree with the trend GARCH-based unit root test. Therefore, we further verify whether accounting for these features when subjecting the stock market indices to unit root testing will enhance the rate of rejections. In addition, understanding the stationarity of stock market indices has implications for policy and forecasting. For instance, if a stock market series is non-stationary, the unit root may be transmitted to other macroeconomic variables. Thus, if there is a shock to stock market, it may spill over to other financial markets such as the bond market, foreign exchange market, money market and commodity market, given its connection with these markets. Also, if a stock series exhibits stationarity, the future values of the series