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Popularity of Unit Root Tests: A Review

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This study undertakes a systematic literature review on recent developments in unit root tests. We highlight popular unit root tests developed since 2010 based on the number of citations. We observe from the literature that the most popular unit root test is the Narayan and Popp unit root test and the least popular test is the quantile nonlinear unit root test, mainly because it was developed only recently. The use and popularity of the recently developed unit root tests can be judged only after 5 to 10 years.

I. Introduction

In time-series analysis, unit root testing plays a pivotal role in the integrational properties of data series. The importance of unit root tests and their development has been emphasized in applied econometrics over the past four decades. This paper undertakes a survey of the unit root literature. This body of literature is large, with voluminous unit root testing approaches; see partial reviews of the unit root literature in Joseph & Perman (2006) and Glynn et al. (2007). The focus on the unit root is important because knowledge of whether unit roots are present in time-series data holds implications for both policy-making and econometric models, as demonstrated, for instance, by Lee & Strazicich (2003), Narayan & Popp (2010), and Narayan & Liu (2015). While it is impossible in a letters-type journal to undertake a full-scale literature survey of the unit root literature given its large volume, we focus on establishing the popularity of unit root tests. We highlight which unit root models are popular and provide reasons. Our objective is to inform readers, particularly those who are in the early stages of research and keen to work in the area of unit root testing.

In Section II below, we present a list of the most popular unit root tests in tabular form. We also identify the least popular tests. We argue that some tests are popular because not only are they easy to handle, but they accommodate key features of data that are of concern to researchers. There may be tests with better properties but they tend to be complex, both in understanding how they work and computationally, making them less appealing to applied researchers. Our goal in this note is not to take sides with any test; rather, we highlight, based on citation evidence from Google Scholar, the most widely used tests. Our survey, then, will appeal to applied researchers, including those at the early stage of their research careers who are undecided on modeling choices with respect to unit root testing. We hope our note offers a helpful guide to these researchers.

II. Summary of the unit root test literature

Table 1 presents popular unit root tests developed and cited (except for Yang & Zhao (2020), and Bec & Alain (2020), which are new and have not yet been cited) in applied research. We cover the past decade beginning with 2010 because this period is marked by development of new tests that account for structural breaks and nonlinearity in particular. Our data source is Google Scholar, which yields 27 unit root tests, as reported in Table 1. Among these, the Narayan & Popp (2010) two structural breaks unit root test (NP test) has received much attention in recent years, with 502 citations as of April 2021. The NP test is popular over other unit root tests, particularly the two endogenous structural breaks tests, for the following reasons. First, the NP test accurately recognizes the break date. This approach requires no prior knowledge for possible timings of the structural breaks, because break dates are endogenously determined within the model. Second, the NP test maximizes the significance of the break dummy coefficients. Third, the NP test assumes similar critical values for both endogenous and exogenous variables in finite samples. Fourth, the NP test can be used over other tests (Lee & Strazicich, 2003; Lumsdaine & Papell, 1997; Zivot & Andrews, 1992) because of its size and power properties (see Narayan & Popp, 2013). The next most popular unit root test based on citations is Enders & Lee (2012a, 2012b), which employs Fourier approximation to test for a unit root without modeling the precise form of the break. Kruse (2011) developed a new unit root test based on modified test statistics; it is considered superior against a nonlinear exponential smooth transition autoregressive model. Overall, the Kruse test is the fourth most popular.

Narayan & Liu (2015) proposed a GARCH-based unit root test that encompasses (i) trending variables; (ii) two en-

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Table 1: A summary of unit root tests.

Author Name	Title	Citation
Narayan, P.K. & Popp, S. (2010)	A new unit root test with two structural breaks in level and slope at unknown time	502
Enders, W. & Lee, J. (2012a)	A unit root test using a Fourier series to approximate smooth breaks	432
Enders, W. & Lee, J. (2012b)	The flexible Fourier form and Dickey–Fuller type unit root tests	250
Kruse, R. (2011)	A new unit root test against ESTAR based on a class of modified statistics	181
Fan, Y. & Gençay, R. (2010)	Unit root tests with wavelets	163
Christopoulos, D.K. & León-Ledesma, M. K. (2010)	Smooth breaks and non-linear mean reversion: Post-Bretton Woods real exchange rates	136
Narayan, P.K. & Liu, R. (2013)	A unit root model for trending time-series energy variables	105
Rodrigues, P.M.M. & Taylor, A.M.R (2012)	The flexible Fourier form and local generalised least squares de-trended unit root tests	95
Cavaliere, G. & Xu, F. (2014)	Testing for unit roots in bounded time series	89
Lee, J. Strazicic, M.C., & Meng, M. (2012)	Two-step LM unit root tests with trend-breaks	77
Kılıç, R. (2011)	Testing for a unit root in a stationary ESTAR process	49
Im, K.S. Lee, J. Tieslau, M.A. (2014)	More powerful unit root tests with non-normal errors	49
Meng, M. Im, K.S. Lee, J. Tieslau, M.A. (2014)	More powerful LM unit root tests with non-normal errors	48
Harvey, D.I. Stephen J. L. & Taylor, A.M.R. (2012)	Unit root testing under a local break in trend	26
Güriş, B. (2019)	A new nonlinear unit root test with Fourier function	22
Park, J.Y. & Shintani, M. (2016)	Testing for a unit root against transitional autoregressive models	17
Chen, C.W.S. Chen, S.Y. & Lee, S. (2013)	Bayesian unit root test in double threshold heteroskedastic models	16
Li, H. & Park, S.Y. (2018)	Testing for a unit root in a nonlinear quantile autoregression framework	16
Omay, T. & Yildirim, D. (2013)	Nonlinearity and smooth breaks in unit root testing	15
Bahmani-Oskooee, M. Chang, T., & Ranjbar, O. (2017)	The Fourier quantile unit root test with an application to the PPP hypothesis in the OECD	12
Vosseler, A. (2016)	Bayesian model selection for unit root testing with multiple structural breaks.	10
Harvey, D.I. Leybourne, S.I. & Taylor, A.M.R. (2014)	Unit root testing under a local break in trend using partial information on the break date	9
Aydin, M. (2019)	A new nonlinear wavelet-based unit root test with structural breaks	3
Westerlund, J. (2013)	Simple unit root testing in generally trending data with an application to precious metal prices in Asia	2
Yang, Y. & Zhao, Z. (2020)	Quantile nonlinear unit root test with covariates and an application to the PPP hypothesis	0
Bec, F. & Alain, G. (2020)	A simple unit root test consistent against any stationary alternative	0

In this table, we note all unit root tests that are available on Google Scholar (GS). We choose GS because it is broad and inclusive of those tests that are not yet cited (the new tests, for instance). The table is organised by number of citations as reported by GS. The citation count appears in Column 3. The title of the paper appears in Column 2, while the authors are acknowledged in Column 1. Sources of citation: Google scholar citation.

dogenously determined breaks; and (iii) heteroskedastic data series. Findings from the GARCH-based unit root test suggest that the trend-based GARCH test outperforms a GARCH model in the absence of a trend. Further, it suggests that including the time trend and breaks is vital in practice to reject the null of unit root. In parallel, a significant development in nonlinear unit root tests has also become substantially more popular in recent years (Chen et al., 2013; Christopoulos & León-Ledesma, 2010; Fan & Gençay, 2010; Güriş, 2019; Li & Park, 2018). Christopoulos & León-Ledesma (2010) made a significant contribution by proposing new test procedures that combine Fourier transformation and nonlinearity. Similarly, the recent Güriş (2019) proposes a new flexible Fourier form of nonlinear unit root test by adding structural breaks and nonlinearity simultaneously. Structural breaks are demonstrated via a Fourier function, and nonlinearity is exhibited through an exponential smooth threshold autoregressive (ESTAR) model. The Güriş (2019) unit root test is potentially superior and more powerful compared to Kruse (2011). Similarly, Vosseler (2016) developed a Bayesian approach to test unit root with the presence of multiple structural breaks by comput-

ing the posterior probability of the distribution. The Aydin & Pata (2020) unit root test is useful for high-frequency data, such as hourly, daily, quarterly and monthly. This test provides consistent results for high-frequency datasets. This unit root test is based on the frequency domain and captures the time information vital for forecasting. This test was first applied with Fourier transforms, but it showed a time dimension deficiency not captured in wavelet-based unit root tests. The same author developed two additional unit root tests, the wavelet-based Kapetanios, Shin and Snell (WKSS) and Fourier wavelet-based Kapetanios, Shin and Snell (FWKSS) nonlinear unit root test with structural breaks (see Aydin, 2019).

III. Concluding remarks

Tests for unit roots depend heavily on the assumptions and properties underlying the models. The unit root tests in time-series data have become increasingly popular over time because of extensive research in applied economics. This review article shows the most popular unit root tests developed over the past decade. We deliberately exclude most of the popular traditional unit root tests and emphasize those unit root tests developed from 2010. We show, based on Google Scholar citations, that the Narayan & Popp (2010) unit root test has emerged as one of the most popular unit root tests. Further, note that these unit root tests are popular because of their ease of application, suitability to time-series data, and are better models to account for structural breaks.

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