The Performance of Variance Ratio Unit Root Tests Under Nonlinear Stationary TAR and STAR Processes: Evidence from Monte Carlo Simulations and Applications

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Abstract This paper investigates the performance of variance ratio unit root tests under nonlinear stationary three-regime threshold autoregressive (TAR) and smooth transition autoregressive (STAR) processes that are significant for some economic theories and variables. Variance ratio unit root tests are effective tools in empirical analysis because they can theoretically consider broad classes of nonlinear stationary processes under the null or alternative hypothesis. Nevertheless, our Monte Carlo simulations demonstrate that these tests perform poorly (with severe size distortions or low power) under stationary TAR and STAR processes. To verify our Monte Carlo results, we apply these tests to yield spreads such as the TAR and STAR processes.

Keywords Variance ratio unit root tests · TAR · STAR · Size distortion · Low power · Yield spread

JEL Classification C12 · C22

1 Introduction

Variance ratio unit root tests have served as popular and effective tools for researchers because not only are they simple to use for calculations of test statistics but also, and more importantly, they can theoretically consider nonlinear stationary processes under the null or alternative hypothesis. Generally, when we test for a unit root, we are uncertain about the true process a priori. In other words, in practice, even if a process is stationary, we are uncertain whether the true process has a stationary linear
autoregressive (AR) process or a nonlinear stationary process a priori. Thus, the correct judgment of whether a time series is characterized by $I(0)$ or $I(1)$ has important implications in economics. In order to guard against distortions in the performance of tests owing to misspecification of the data generating process (DGP), it is recommended that applied researchers employ tests that consider general stationary processes. Accordingly, when the true process is nonlinear stationary, it is expected that these tests should perform better than standard unit root tests, represented by Dickey and Fuller (1979), that assume only a linear AR process.

This paper investigates the performance of variance ratio unit root tests under nonlinear stationary processes. We focus on the variance ratio unit root tests of Kwiatkowski et al. (1992) and Breitung (2002). Kwiatkowski et al. (1992) tested for the null hypothesis $I(0)$ against $I(1)$; contrarily, Breitung (2002) tested for the null hypothesis $I(1)$ against $I(0)$. We examine the performance, inter alia, under the three-regime threshold autoregressive (TAR) and smooth transition autoregressive (STAR) processes that are significant for some economic theories. One of the most representative theories is the purchasing power parity theory. Dumas (1992) and Sercu et al. (1995) proposed theoretical models involving the nonlinear adjustment of the real exchange rate in the presence of transaction costs. Obstfeld and Taylor (1997), Michael et al. (1997), and Taylor et al. (2001) conducted empirical studies of TAR and STAR processes regarding purchasing power parity. Similarly, Anderson (1997), Clements and Galvéo (2003), and Maki (2006) conducted empirical studies of TAR and STAR processes concerning term structure of interest rates.

Standard unit root tests assume only linear adjustments; however, the variance ratio unit root tests investigated in this paper do not specify short-run dynamics and can therefore theoretically analyze nonlinear stationary processes such as TAR and STAR without misspecification of the DGP. As pointed out by Pippenger and Goering (1993) and Balke and Fomby (1997), most unit root tests represented by Dickey and Fuller (1979) have a low power against stationary three-regime TAR processes. Further, Enders and Granger (1998) demonstrated that the Dickey–Fuller (DF) test had a low power under three-regime TAR processes. Taylor et al. (2001) discussed the power of the DF test under STAR processes and provided results of its poor performance. Accordingly, when the true process has a three-regime TAR or STAR process, while the standard approach entails that stationarity is not often found, it is possible that the variance ratio unit root tests that consider nonlinear stationary processes can successfully find stationarity. Contrary to expectations, however, it is found that the reduction in power or the distortion of size is rather large when the nonlinear effect in nonlinear stationary processes is large. To verify our Monte Carlo results, we apply these tests to yield spreads such as the three-regime TAR and STAR processes. Further, the empirical applications also indicate that nonlinear effects have a more significant impact on the properties of variance ratio unit root tests.

The remainder of this paper is organized as follows. Section 2 reviews variance unit root tests. Section 3 investigates the power and size of the models reviewed in Sect. 2, using Monte Carlo simulations. Section 4 presents the empirical applications for the yield spreads. Finally, Sect. 5 summarizes the paper.