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# This Week's Citation Classic®

**Dickey DA& Fuller W A.** Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica* 49:1057-72, 1981. [North Carolina State University, Raleigh, NC; and Iowa State University, Ames, IA]

A statistical test distinguishing deterministic trends from random but highly correlated sequences is developed. This allows one to assess the long-run impact of unanticipated economic shocks. The test can be applied to linear combinations of two or more series to check for a stable long-run relationship. [The *SSCI*® and the *SCI*® indicate that this paper has been cited in more than 420 publications.]

## A Statistical Test for Stability

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This article arose from my dissertation work with Wayne A. Fuller at Iowa State University and is included in his textbook.[1] The work centers on distinguishing series that are accumulations of random steps from series exhibiting stable movement around simple functions such as constants or linear trends over time, so-called trend stationary processes.

I anticipated applications to forecasting. I am like a medical researcher who invents a cure for warts only to find it happens to cure cancer, too. The forecasting application is relatively unimportant, but many critical questions in economics, for example, behavior of exchange rates, gross domestic product, and wage-price relationships, boil down to unit root tests. I did not realize this butfortunately Charles R. Nelson and Charles I. Plosser did.[2] Their *Citation Classic*® explains the role of trend stationarity in economics. Fuller and I chanced to have lunch with Plosser at a meeting and discussed our work. That encounter resulted in his paper with Nelson, bringing our work to applied econometricians.

I recall toiling over a 10-page development of a certain needed result on matrix eigenvalues while simultaneously searching for it in the literature. After a few months, I finally got the result only to find it a few weeks later in a journal not ofte referenced by Statisticians.[3] The ten pages I was so proud of ended up as a dissertation appendix. I also recall a famous statistician visiting Iowa State and telling me that he had also thought about my dissertation problem once and had all the results scratched out on a piece of paper in his desk drawer. Panic time! Fortunately for me, his claim wasn't quite accurate. Publication in *Econometrica* went smoothly and quickly thanks to Christopher Simms and his referees.

As it happens, this test can be used in verifying relationships between economic variables. If one speculates that the difference between long- and short-term interest rates is stable over time, this can be tested by simply running a unit root test on the difference of the two rates. Some clever extensions of these tests in multivariate series, known collectively as cointegration analysis, can be used to search for stable economic relationships. The *Citation Classic* of Robert F. Engle and Clive W.J. Granger describes a seminal article[4] along these lines.

Getting the distribution of the test statistic was difficult but actually doing the test is easy. All one need do is run a regression program. It is based on the well-known likelihood principle and extends to a fairly broad class of time series models. The simplicity and classical foundation of the test are major reasons for its popularity. The extension to cointegration by other authors and their kind referencing of our early work have kept interest high.

1. **Fuller W A.** *Introduction to statistical time series.* New York: Wiley, 1976. 470 p. (Cited 790 times.)
2. **Nelson C R & Plosser C L** Trends and random walks in macroeconomic time series: some evidence and implications. *J. Monetary Econ.* 10:139-62. 1982. (Cited 445 times.) [See also: Nelson C R. The two-Charlies paper: is GNP a random walk? Citation Classic®. *Current Contents®/Social & Behavioral Sciences* 25(28):3. 12 July 1993, *and Currem Contents/Arts & Humanities* 15(15):14, 19 July 1993.]
3. **Rutherford D E.** Some continuant determinants arising in physics and chemistry. *Proc. Roy. Soc. Edinburgh Sec A* 62:22-36. 1946.
4. **Engle R F & Granger C W J.** Co-integration and error correction: representation, estimation, and testing. *Econometrica* 55:251-76, 1987. (Cited 685 times.) [See also: Engle R F & Granger C W J. Cointegration—the early days. Citation Classic. *Current Contenls/Sociai & Behavioral Sciences* 25(2):8. 11 January 1993. and *Current Conlenls/Arts & Humanities* 15(2):22. 18 January 1993.]

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