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Physics Procedia 3 (2010) 1753–1756
Physics Procedia
www.elsevier.com/locate/procedia

KSS Unit Root Test of Nonlinearity and Nonstationarity in China's Agricultural Futures Markets

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Abstract

Unit root tests are the starting points of most economic time series analyses. Based on the nonlinear unit root test proposed by Kapetanios, Shin and Shell (KSS), this article propose a procedure to detect the presence of nonstationarity against nonlinear processes in 5 representative China's agricultural futures markets. Our results illustrate that a unit root is rejected in favor of nonlinear trend stationary for these markets; therefore, the results in current literature based on the linear hypothesis may be spurious in understanding true market's dynamics. We contribute to current literature in providing for the first time the empirical evidence of these facts in China's agricultural futures markets, which is fundamentally important in relevant researches.

Keywords: China's agricultural futures markets; Nonlinearity; Nonstationarity; KSS unit root test

1. Introduction

Most studies in current literature of China's agricultural futures markets are based on the assumption of multivariate normality, for example, cointegration theory proposed by Engle and Granger [1]. Many researchers used the unvouched hypotheses that the prices (returns) time series of the commodity futures markets follow Random-Walk Hypothesis (RWH) and that the relationships between different markets are linearly co-integrated. Many researchers analyzed empirically the relationship between futures price and spot price by cointegration theory, and found that most varieties of futures price and the futures spot price existed cointegration relationships [2-6].

Most studies in current literature tend to use unit root test based on the linear assumption. Nelson and Plosser [7] proposed that the economic series are better characterized by unit roots. Engle suggested it should test unit root of time series before cointegration test and proposed the Augmented Dickey–Fuller (ADF) test [8]. Since then, the analysis of unit roots of macroeconomic variables has become an increasingly popular topic, and unit root tests become the starting points of most economic time series analyses. But many studies pointed out that ADF unit root test gives the poor performance in small-sized samples [9-11], fractional integration [12, 13] and nonlinearities [14-16]. The ADF test underestimates the speed of adjustment of the long-run equilibrium.

There is a growing dissatisfaction with the hypothesis of traditional unit root test which does not consider any nonlinearity in the deterministic components. An incorrect specification of the deterministic components might affect the validity of the test. Kapetanios, Shin and Shell proposed asymptotic critical values of the tNL statistics was tabulated via Monte Carlo stochastic simulations, and then applied the method to ex post real interest rates and

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doi:10.1016/j.phpro.2010.07.015

bilateral real exchange rates with the US Dollar from the 11 major OECD countries, and found KSS test was able to reject a unit root in many cases, whereas the linear DF tests fail, providing some evidence of nonlinear mean-reversion in both real interest and exchange rates [16]. By means of KSS tests, many other empirical results found that the time series of real exchange rates are nonlinear trend stationary [17-22].

In the current context of China's agricultural futures markets, unit root tests are mainly based on linear assumptions, ignoring the fact of the existence of nonlinearity in the markets [23-25]. Hung-Gay Fung, Wai K. Leung and xiaoqing Eleanor Xu [23] using generalized auto-regressive conditional heteroscedastic (GARCH) model examined patterns of information flows for three commodity futures traded in the China's soybeans and wheat futures markets. Du and Wang [24] also applied GARCH model to study China's wheat futures market. However, their stationarity unit root tests are based on linear hypotheses. As a result, their conclusions may be spurious. Up to now, there is still lack of any result of KSS nonstationarity based on nonlinear assumption in China's agricultural futures markets domain.

2. Theory and methods

KSS test is applied to test equation by adding the index of the transfer function to test nonlinear adjustment characteristics. KSS is given by the following ESTAR specification:

$$\Delta y_t = \gamma y_{t-1}\left[1-\exp\left(-\theta y_{t-1}^2\right)\right]+\varepsilon_t \qquad (\theta \geq 0) \tag{1}$$

where y_t is the demeaned or detrended time series of interest, while γ is unknown parameter and ε_t is an i.i.d. error with zero mean and constant variance. Furthermore, $\left[1-\exp\left(-\theta y_{t-1}^2\right)\right]$ is the exponential transition function adopted in the test to present the nonlinear adjustment.

The null hypothesis is $H_0:\theta=0$, while the alternative hypothesis is $H_1:\theta>0$. Under the null hypothesis, y_t follows a linear unit root process, whereas it is a non-linear stationary ESTAR process under the alternative. Because the null hypothesis $H_0:\theta=0$ cannot be directly tested, KSS suggest to reparameterize Eq.(1) by computing a first-order Taylor series approximation to specify Eq.(1) to obtain the auxiliary regression given by

$$\Delta y_t = \delta y_{t-1}^3 + \varepsilon_t \tag{2}$$

For a more general case where the errors in Eq.(2) are serially correlated, regression of Eq. (2) is extended to

$$\Delta y_t = \sum_{j=1}^{p} \rho_j \Delta y_{t-j} + \delta y_{t-1}^3 + \varepsilon_t \tag{3}$$

with the ρ augmentations to correct for serially correlated errors. The lag is determined through the AR models. The null hypothesis of nonstationarity to be tested with either Eq.(2) or Eq.(3) is $H_0:\delta=0$ against the alternative $H_1:\delta<0$. Asymptotic critical value of the tNL statistics is given by

$$t_{NL} = \hat{\delta} / s.e.\left(\hat{\delta}\right) \tag{4}$$

where $\hat{\delta}$ is the OLS estimate of δ and $s.e.\left(\hat{\delta}\right)$ is the standard error of $\hat{\delta}$. The t_{NL} statistics does not obey an asymptotic standard normal distribution.

3. Empirical analysis

3.1 Data

We selected daily closing price time series of five representative futures contracts of China's agricultural futures markets, i.e., corn (from September 22, 2004 to January 23, 2009), hard wheat (from December 28, 1993 to January 23, 2009), strong wheat (from March 28, 2003 to January 23, 2009), No.1 soybean (from March 15, 2002 to January 23, 2009) and soy meal (from July 17, 2000 to January 23, 2009), including 1057, 3045, 1416, 1655, and 2039 data points respectively. All our data are taken from Reuters Database©. In this article, CC, HW, SW, SB1and SM represent futures price series of corn, hard wheat, strong wheat, No.1 soybean and soy meal respectively. From Fig.1, the time-varying volatility patterns are obviously consistent with the nonlinear characteristics.

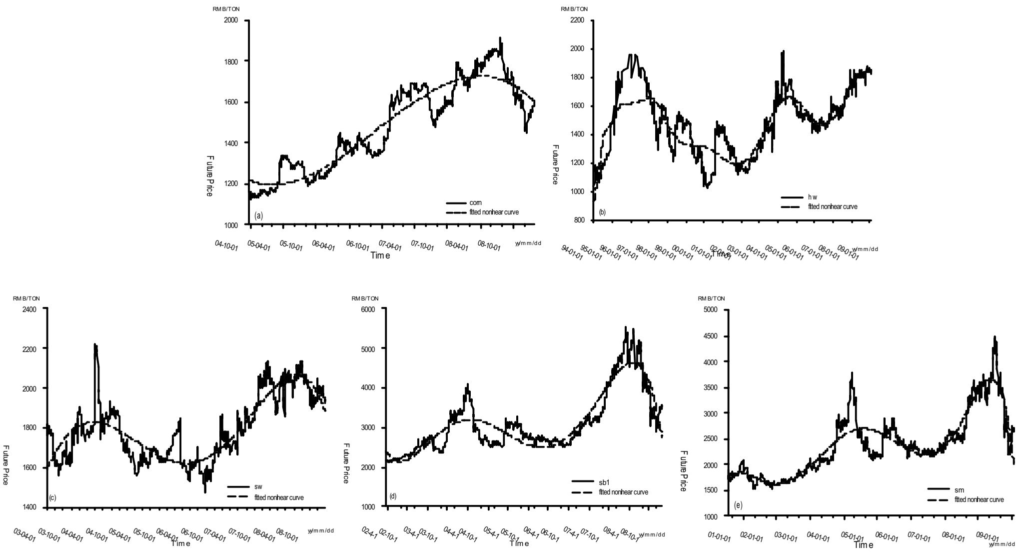

Fig.1 the price time series of five futures contracts, i.e., (a) corn, (b) hard wheat, (c) strong wheat, (d) No.1 soybean and (e) soy meal, where the dotted lines are fitted nonlinear trends using polynomial fit method

3.2 KSS test

From Table 1, we can find the obvious departure from Gaussian normal distribution for all the series. Therefore, the traditional unit root test may lead to spurious conclusion, and a KSS test should be applied to the market analyses.

Table 1 Skewness, Kurtosis and Jarque-Bera Test

Series	Skewness	Kurtosis	Jarque-Bera test	
			Value	Probability
CC	0.044268	1.746577	69.53769	0.00
HW	0.022889	2.202649	80.90239	0.00
SW	0.442987	2.142525	89.69263	0.00
SB1	1.246029	3.781176	470.3364	0.00
SM	0.892487	3.317182	279.2358	0.00

Table 2 KSS unit root test results

Series	KSS	Significant Level
		10%
CC	-1.57	-2.66
HW	-3.38	-2.66
SW	-2.75	-2.66
SB1	-2.96	-2.66
SM	-2.12	-2.66

After demeaning, we obtained KSS unit root test results (see Table 2). At 10% significant Level, the corn and soy meal series accept null hypothesis, that is, they are stationary series; while hard wheat, strong wheat and No.1 soybean reject null hypothesis, which imply they are nonlinear trend stationary. As for the latter 3 markets, the traditional unit root test is based on linear assumption may lead to false results, as Bigman et al pointed out that the traditional method of testing unbiasedness is not valid and tends to produce "spurious regression" if the price series are nonstationary [26]. The nonlinear-stationary structures existing in these markets also imply that price changes are not constant and exhibit nonlinear characteristics. Our results are consistent with the facts observed in the futures market fluctuations.

4. Conclusions

In China's agricultural futures markets, hard wheat, strong wheat and No.1 soybean are nonlinear trend stationary, and show nonlinear characteristics. Therefore, to avoid spurious regression, we suggest non-linear analysis methods should be used to describe the futures price fluctuations instead of linear methods in current literature.

Acknowledgements

The author would like to thank anonymous referees for valuable comments and suggestions. This work is supported by Chinese Universities Scientific Fund (№ 2009-1-23), China Postdoctoral Science Foundation (№ 20090450602), XU Guo-Zhi Postdoctoral Foundation, and Joint Open Young Scholar Science Foundation of CAU & NJAU (№ CN2007010).

References

[1] R. F. Engle and C. W. J. Granger, Cointegration and error correction representation estimation and testing Econometrica, 55 (1987) 251.
[2] K. Lai and M. Lai, A cointegration test for market efficiency, Journal of Futures Markets, 11 (1991) 567.
[3] A. Ghosh, Cointegration and error correction models:interemporal causality between index and futures prices, Journal of Futures Markets, 13 (1993) 193.
[4] T. R. Fortenbery and H. O. Zapata, An evaluation of price linkagesbetween futures and cash markets for cheddar cheese, Journal of Futures Markets, 17 (1997) 279.
[5] M. Kavussanos and N. Nomikos, The forward pricing function of the shipping freight futures market, Journal of Futures Markets, 19 (1999) 353.
[6] M. S. Haigh, Cointegration,Unbiased expectations,and forecasting in the BIFFEX freight futures market, Journal of Futures Markets, 20 (2000) 545.
[7] C. R. Nelson and C.I.Plosser, Trends and random walks in macroeconomic time series, Journal of Monetary Economics, 10 (1982) 139.
[8] A. D. Dickey and W. A. Fuller, Likelihood ratio statistics for autoregressive time series with unit root Econometrica, 49 (1981) 1057.
[9] P. C. B. Phillips, Time series regression with a unit root, Econometrica, 55 (1987) 311.
[10] P. C.B.Phillips and P. Perron, Testing for a unit root in time series regression, Biometrika, 75 (1988) 335.
[11] D. Kwiatkowski, P.C.B.Phillips, P.Schmidt and Y.Shin, Testing the null hypothesis of stationarity against the alternative of a unit root:How sure are we that economic series have a unit root?, Journal of Econometrics, 54 (1992) 159.
[12] J. Geweke and S.Porter-Hudack, The estimation and application of long memory time series models and fractional differencing, Journal of Time Series Analysis, 4 (1983) 221.
[13] P. M. Robinson, Effcient tests of nonstationary hypotheses, Journal of the American Statistical Association, 89 (1994) 1420.
[14] H. J. Bierens, Testing the unit root with drift hypothesis against nonlinear trend stationarity,with an application to the U.S.price level and interest rate, Journal of Econometrics, 81 (1997) 29.
[15] S. Leybourne, P.Newbold and D.Vougas, Unit roots and smooth transtions, Journal of Time Series Analysis, 19 (1998) 83.
[16] G. Kapetanios, Y. Shin and A. Snell, Testing for a unit root in the nonlinear STAR framework, Journal of Econometrics, 112 (2003) 359.
[17] N. Ucar and T. Omay, Testing for unit root in nonlinear heterogeneous panels, Economics Letters, 104 (2009) 5.
[18] R. Kili, Further on nonlinearity, persistence, and integration properties of real exchange rates, Journal of International Financial Markets, Institutions and Money, 19 (2009) 207.
[19] T. Chang and S. B. Caudill, A note on the long-run benefits from international equity diversification for a Taiwan investor diversifying in the US equity market, International Review of Financial Analysis, 15 (2006) 57.
[20] V. K.-s. Liew, A. Z Baharumshah and T. T.-l. Chong, Are Asian real exchange rates stationary?, Economics Letters, 83 (2004) 313.
[21] H.-Y. Yau and C.-C. Nieh, Testing for cointegration with threshold effect between stock prices and exchange rates in Japan and Taiwan, Japan and the World Economy, 21 (2009) 292.
[22] S. Zhou, Stationarity of Asian-Pacific real exchange rates, Economics Letters, 98 (2008) 16.
[23] H.-G. Fung, W. K. Leung and X. E. Xu, Information Flows Between the U.S.and China Commodity Futures Trading, Review of Quantitative Finance and Accounting, 21 (2003) 267.
[24] W. Du and H. H. Wang, Price behavior in China's wheat futures market, China Economic Review, 15 (2004) 215.
[25] R. Hua and B. Chen, International linkages of the Chinese futures markets, Applied Financial Economics, 17 (2007) 1275.
[26] D. Bigman, D. Goldfarb and E. Schechtman, Futures market efficiency and the time content of the information sets, Journal of Futures Markets, 3 (1983) 321.