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MEAN REVERSION IN STOCK PRICES OF G7 COUNTRIES: EVIDENCE FROM PANEL SURADF AND PANEL SURKSS TESTS

In this study we investigate the behaviour of stock prices in G7 countries for 2000:01-2007:12 period employing panel SURADF and panel SURKSS tests. While the results of panel SURADF test show each member of the panel has a unit root, the results of panel SURKSS test indicate only the stock prices of the UK and the US are nonlinear stationary which indicate that abnormal returns can be earned at these stock markets by predicting future prices using past movements of the prices.

Keywords: *mean reversion; nonlinearity; panel SURADF test; panel SURKSS test; stock prices.*

Jel Codes: C23; G14; G15.

Вєлі Їланчі

ЗАКОН ЧЕРГУВАННЯ ДЛЯ ЦІН НА ФОНДОВИХ РИНКАХ КРАЇН "ВЕЛИКОЇ СІМКИ": ЗА ДАНИМИ ПАНЕЛЬНИХ ТЕСТІВ SURADF ТА SURKSS

У статті досліджено поведінку фондових цін у країнах "великої сімки" за даними 2000-2007 рр., використано панельні тести SURADF та SURKSS. За результатами теста SURADF, кожен член панелі має одиничний корінь. Результати тесту SURKSS показали, що ціни на фондових ринках Великої Британії та США є нелінійними та стаціонарними, тобто аномальна прибутковість на даних ринках може бути отримана шляхом прогнозування майбутніх цін виходячи з минулих.

Ключові слова: *закон чергування; нелінійність; панельний тест SURADF; панельний тест SURKSS; ціни на фондових ринках.*

Форм. 2. Табл. 2. Літ. 19.

Вели Йиланчи

ЗАКОН ЧЕРЕДОВАНИЯ ДЛЯ ЦЕН НА ФОНДОВЫХ РЫНКАХ СТРАН "БОЛЬШОЙ СЕМЕРКИ": ПО ДАННЫМ ПАНЕЛЬНЫХ ТЕСТОВ SURADF И SURKSS

В статье исследуется поведение фондовых цен в странах "большой семерки" по данным 2000-2007 гг., применены панельные тесты SURADF и SURKSS. По результатам теста SURADF, каждый член панели имеет единичный корень. Результаты теста SURKSS показали, что цены на фондовых рынках Великобритании и США нелинейны и стационарны, т. е. аномальная доходность на данных рынках может быть получена путем прогноза будущих цен исходя из прошлых.

Ключевые слова: *закон чередования; нелинейность; панельный тест SURADF; панельный тест SURKSS; цены на фондовых рынках.*

1. Introduction. Investigating the mean reversion characteristics of stock prices is one of the popular topics in empirical finance, which can be examined by employing unit root tests. If stock prices are stationary, that is characterized by a mean reversion process, the shocks will have transitory effects on stock prices, which implies future movements can be predicted by examining past movements of prices, so investors can

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develop different trading strategies to earn abnormal returns. On the other hand, in the case when stock prices follow a unit root process, the shocks have permanent effects. Therefore, the future prices are unpredictable when using past prices and in the long run stock markets volatility will increase without bound (Narayan, 2008).

Although there are numerous studies testing stationarity properties of stock prices, there is no consensus since results are mixed. Several studies use linear univariate unit root tests (see Choudhry, 1997 and Buguk and Brorsen, 2003 inter alia), which are criticized since linear univariate unit root tests have low power for small samples. Thus, several studies investigate the stationarity properties of stock prices in a linear panel framework to gain more power (see Narayan, 2007; Lee et al., 2010 and Luet al., 2010 among others). But these studies can be also criticized because linear unit root tests will become inappropriate as mentioned in Taylor and Peel (2000) if the true process of data generation is nonlinear because of the reasons such as existence of heterogeneous agents (Killian and Taylor, 2003), transaction costs (McMillan, 2003), taxes and regulations. In this context there are also some other studies, which extend the literature by considering nonlinearity in the data generation process and employ individual nonlinear unit root tests (see Narayan, 2006; Murthy et al., 2011; Li and Chen, 2010 and Mishra and Mishra, 2011 among others).

In this study, we contribute to the literature by using series specific linear and nonlinear panel unit root tests. Thus, we aim to gain more power than in univariate linear and nonlinear unit root tests. To the best of our knowledge, this is the first study, which attempts to use nonlinear panel unit root tests to examine the stationarity of stock prices. For this purpose, in the following section we summarize the econometric methodology, in the third section we describe the data and present the empirical results and in the last section we conclude the paper.

2. Econometric Methodology

2.1. Panel SURADF Test. In their study Breuer et al. (2001, 2002) claim that rejection of the null hypothesis of unit root, by using standard panel unit root tests does not imply all the members of the panel are stationary because of their "all or nothing" nature. Therefore, they introduce a panel unit root test which is based on estimation of the sequence of augmented Dickey Fuller (ADF) test models by seemingly unrelated regression (SUR) approach. Using this technique we can overcome the drawback of standard panel unit root tests such as giving no information about how many series or which of them are stationary. The following equations show the system of ADF equations to be estimated employing the SUR procedure:

$$
\begin{aligned}
\Delta y_{1,t} &= \alpha_1 + \delta_1 y_{1,t-1} + \sum_{j=1}^{p_1} \beta_{1,j} \Delta y_{1,t-j} + \varepsilon_{1,t} \qquad t = 1,\ldots,T \\
\Delta y_{2,t} &= \alpha_2 + \delta_2 y_{2,t-1} + \sum_{j=1}^{p_2} \beta_{2,j} \Delta y_{2,t-j} + \varepsilon_{2,t} \qquad t = 1,\ldots,T \\
&\vdots \\
\Delta y_{N,t} &= \alpha_N + \delta_N y_{N,t-1} + \sum_{j=1}^{p_N} \beta_{N,j} \Delta y_{N,t-j} + \varepsilon_{N,t} \qquad t = 1,\ldots,T
\end{aligned}
\qquad (1)
$$

Where y_i shows the stock prices, $\delta_i - 1 = \rho_i$ denotes autoregressive coefficient for series i, and ε_i is the error term. This system allows for both heterogeneous fixed effects and lags for each cross sections in the panel. We test the N null and N alternatives hypotheses individually:

$$\begin{array}{ll} H_0^1 : \delta_1 = 0 & H_A^1 : \delta_1 < 0 \\ H_0^2 : \delta_2 = 0 & H_A^2 : \delta_2 < 0 \\ \vdots & \\ H_0^N : \delta_N = 0 & H_A^N : \delta_N < 0 \end{array}$$

We compute the test statistics using the t-ratios of the first order autoregressive coefficients from the SUR estimates of system 1. The critical values, which are specific to the sample size, the number of panel members, lag structure and the estimated covariance matrix for the series tested, are obtained via Monte Carlo simulations.

2.2.Panel SURKSS Test. When the true data generation process is nonlinear, using linear unit root tests can give biased results. Therefore, Wu and Lee (2009) developed a series specific nonlinear panel unit root test similar to the panel SURADF test by Breuer et al. (2001, 2002). They extend the panel SURADF test using Kapetanios et al. (2003) KSS test equations instead of ADF equations. We estimate the following system of KSS equations using the SUR procedure in this test:

$$\begin{array}{ll} \Delta y_{1,t} = \delta_1 y^3_{1,t-1} + \sum_{j=1}^{p_1} \beta_{1,j} \Delta y_{1,t-j} + \varepsilon_{1,t} & t = 1,\ldots,T \\ \Delta y_{2,t} = \delta_2 y^3_{2,t-1} + \sum_{j=1}^{p_2} \beta_{2,j} \Delta y_{2,t-j} + \varepsilon_{2,t} & t = 1,\ldots,T \\ \vdots & \\ \Delta y_{N,t} = \delta_N y^3_{N,t-1} + \sum_{j=1}^{p_N} \beta_{N,j} \Delta y_{N,t-j} + \varepsilon_{N,t} & t = 1,\ldots,T, \end{array} \tag{2}$$

where y_i is demeaned or detrended series of interest. We test the N null and N alternatives hypotheses individually:

$$\begin{array}{ll} H_0^1 : \delta_1 = 0 & H_A^1 : \delta_1 < 0 \\ H_0^2 : \delta_2 = 0 & H_A^2 : \delta_2 < 0 \\ \vdots & \\ H_0^N : \delta_N = 0 & H_A^N : \delta_N < 0 \end{array}$$

The statistics in testing these hypotheses are computed from the SUR estimates of system 2. Since this test has nonstandard distributions, we obtain the critical values by simulation. As Breur et al. (2001) stated, imposition of identical lag structures across panel members could bias the test statistics, so we select optimal lag orders for each equation in the systems using general to specific t-significance method by determining the maximum lag order following Schwert (1989) for both panel SURADF and panel SURKSS tests.

3. Data and Empirical Results

We employ the monthly stock prices of G7 countries from January 2000 to December 2007 and use the natural logs of them for the analysis. We first apply panel SURADF unit root test, and present the test results in Table 1. The results show each of the series of the panel has a unit root. This implies that stock prices in G7 countries are not mean reverting.

Table 1. **Results of Panel SURADF Unit Root Test**

Countries	SURADF	CV %10	CV %5	CV %1
Canada	-2.6046 (4)	-4.7922	-4.1739	-3.818
France	-2.1327(1)	-5.1496	-4.5383	-4.2269
Germany	-0.9678(10)	-4.9283	-4.3424	-4.0425
Italia	-3.0051(2)	-5.0439	-4.4023	-4.0607
Japan	-2.1518(0)	-4.2071	-3.5757	-3.2616
UK	-2.1818(6)	-4.9676	-4.3884	-4.0814
US	-2.8743(5)	-5.036	-4.4237	-4.1138

Note: Numbers in parentheses show the optimal lag length. Critical values are calculated by Monte Carlo simulation using 10000 draws that are tailored to the sample size.

Since the linear unit root tests lose power in the case of nonlinear data generation process, we next use the panel SURKSS test. Table 2 presents the results of this test. We reject the null of unit root only for the stock prices of the UK and the US which implies nonlinear stationarity for these stock prices.

Table 2. **Results of Panel SURKSS Unit Root Test**

Countries	SURKSS	CV %10	CV %5	CV %1
Canada	-2.8794 (8)	-4.7075	-4.0506	-3.7259
France	-3.7279 (5)	-5.2879	-4.6604	-4.3215
Germany	-3.9914 (6)	-5.1811	-4.5347	-4.2035
Italia	-3.7464 (3)	-4.906	-4.2515	-3.9397
Japan	-2.1646 (1)	-4.2224	-3.5404	-3.2031
UK	-4.6132 (7)**	-5.0774	-4.4664	-4.1323
US	-5.1395 (7)**	-5.1452	-4.4656	-4.1199

Note:** shows the significance at the 0.05 level. Numbers in the parentheses show the optimal lag length. Critical values are calculated by Monte Carlo simulation using 10000 draws that are tailored to the sample size.

To sum up, only the results of the panel SURKSS test give evidence of stationarity only for two country's stock prices – the UK and the US. Some policy implications emerge from these findings. First, the stationarity of the UK and the US stock prices show that shocks to stock prices have a temporary effect, so future prices can be predicted based on historical movements, and trading strategies can be developed to earn abnormal returns. Second, as mentioned by Lu et al. (2010) spurious causality would result, if the data were treated as non-stationary by mistake and the causality tests were applied to the first differences. Third, the stationarity of stock prices increase the attractiveness of relevant stock markets for long-term investors since low returns are followed by higher expected future returns (see Vlaar, 2005) and fourth, the government financial policy may not require intervention policies at the stock market, since for a sustainable strategy targeting non-increasing stock prices may be feasible (Lee et al. 2010).

4. Conclusion. This paper investigates the mean reversion characteristics of the G7 stock prices using the monthly data from 2000:01 to 2007:12. For this purpose, we use linear panel SURADF and nonlinear panel SURKSS tests. While the results of panel SURADF test show that each of the stock prices in G7 countries has a unit root, the results of the panel SURKSS test show that only the stock prices of the United Kingdom and the United States are nonlinear stationary. These results show the importance of considering nonlinearity in examining the mean reversion characteristics of stock prices.

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