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Efficient market hypothesis in emerging markets: Panel data evidence with multiple breaks and cross sectional dependence

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Abstract

The purpose of this paper is to re-examine whether mean reversion property hold for 15 emerging stock markets for the period 1985 to 2006. Utilizing a panel stationarity test that is able to account for multiple structural breaks and cross sectional dependence, we find that the emerging stock markets follow a random walk process. However, further analysis on individual series show that the majority of stock prices in emerging markets are governed by a mean reverting process. This result, which is inconsistent with efficient market hypothesis, suggests that past information is useful in predicting future prices in most of the markets.

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1. Introduction

There has been much interest in prior empirical studies in testing whether stock price follows a random walk or mean reverting process. The mean reversion of the stock prices would suggest that current prices are predictable based on the previous prices, which is inconsistent with the weak-form efficient market hypothesis. Conversely, if stock prices follow a random walk process (unit root) any shock will have a permanent effect on stock prices. As a consequent, stock prices will reach a new equilibrium point and, therefore, future prices cannot be predicted based on their historical movements.

Several studies have tested the validity of the random walk hypothesis (see Chen *et al.*, 2002; Ratanapakorn and Sharma, 2002; Chaudhuri and Wu, 2003; Phengpis, 2006; and Narayan, 2008, among many others). Using data from both developed and developing countries they find no homogenous conclusion on the subject matter. For instance, Chaudhuri and Wu (2003) and Phengpis (2006) have provided conflicting empirical evidence on the stochastic properties of stock prices in ten emerging markets using univariate unit root test that account for a single structural break.[1] While Chaudhuri and Wu (2003) find that the stock prices are mean reverting, Phengpis (2006), who use a different unit root test, find that the majority of the stock prices can be characterized as a random walk process. One possible explanation for this conflicting finding may be the failure of the aforementioned studies to accommodate possible multiple structural breaks and cross sectional dependence in stock prices. The importance of multiple structural breaks should not be underestimated since equity markets are affected by several important events over the past few decades such as stock market liberalization, economic crises, and changes in economic policy (Bekaert *et al.*, 2002; Henry, 2000). Perron (1989) show that the failure to take into account possible breaks in the series may lead to undersized test statistic, leading to incorrect inferences. In addition, it is unrealistic to assume that individual stock markets are cross sectionally independent. The importance of cross sectional dependence seems especially relevant here since most of the countries under consideration are trade-oriented. Therefore, any shocks to a country's stock market could be easily be transmitted across borders via imports and exports. Moreover, emerging stock markets are likely to be affected by common external effects such as the business cycles of the United States. This conjecture is confirmed by our results using a formal test proposed by Breusch and Pagan (1980). Maddala and Wu (1999) point out that the failure to accommodate cross sectional dependence in panel unit root and stationarity tests may lead to severe size distortions.

The objective of this paper is to re-examine the stochastic properties of stock prices in 15 emerging markets. Our main contribution is that we employ a new panel stationarity test due to Carrion-i-Silvestre *et al.* (2005) which is flexible enough to accommodate an unknown number of multiple breaks and cross-sectional dependence across stock markets. We also investigate the stochastic properties of individual stock prices using the test proposed by Im *et al.* (2005). The results of our study will complement, or possibly alter, the conclusions documented in previous studies particularly by Chaudhuri and Wu (2003) and Phengpis (2006).

[1] These countries are Argentina, Brazil, Greece, India, Malaysia, Mexico, Nigeria, Philippines, Taiwan, and Zimbabwe.

The rest of the article is organized as follows. Section II describes the empirical methodology. Section III presents the data and empirical analysis, and the final section concludes.

2. Methodology

In this paper, we rely on two newly developed panel test to establish the stochastic properties of stock prices in 15 emerging market. They are panel stationarity test by Carrion-i-Silvestre *et al.* (2005) and panel unit root test by Im *et al.* (2005). Both tests allows for multiple structural breaks in the series.[2]

The panel stationarity by Carrion-i-Silvestre *et al.* (2005) is a generalized version of the Hadri's (2000) panel stationarity test for the case of multiple structural breaks. Let $y_{i,t}$ be the stochastic process of stock prices which under the null hypothesis is characterized by the following data generation process:

$$y_{i,t} = \alpha_{i,t} + \beta_i t + \varepsilon_{i,t} \tag{1}$$

where

$$\alpha_{i,t} = \sum_{k=1}^{m_i} \theta_{i,k} D(T_{b,k}^i)_t + \sum_{k=1}^{m_i} \gamma_{i,k} DU_{i,k,t} + \alpha_{i,t-1} + \upsilon_{i,t} \tag{2}$$

where $\upsilon_{i,t} \sim$ i.i.d. $(0,\sigma_{v,i}^2)$ and $\alpha_{i,0} = \alpha_i$, constant with i = 1,….., N individuals and t = 1, …,T time periods. The dummy variables $D(T_{b,k}^i)_t$ and $DU_{i,k,t}$ are defined as $D(T_{b,k}^i)_t$ = 1 for t = $T_{b,k}^i$ and 0 elsewhere and $DU_{i,k,t}$ =1 for t > $T_{b,k}^i$ and 0 elsewhere. The Carrion-i-Silvestre *et al.* (2005) method includes individual structural break effect (shifts in the mean) if $\beta_i \neq 0$ and temporal structural break effect (shifts in the individual time trend) if $\gamma_{i,k} \neq 0$. The specification above has three characteristics. Firstly, structural breaks can have different effects on each individual time series specified by $\theta_{i,k}$ and $\gamma_{i,k}$. Secondly, structural breaks can occur at different locations since there is no restriction on the dates of the breaks, $T_{b,k}^i \neq T_{b,k}, \forall = \{1,..,N\}$ and thirdly, individuals can have different numbers of structural breaks which is captured by $m_i \neq m_j, \forall_i \neq j, i, j = \{1,...,T\}$. Based on the stationarity test proposed by Hadri (2000), the general expression for the test statistics is

$$LM(\lambda) = N^{-1} \sum_{i=1}^{N} (\hat{\omega}_i^{-2} T^{-2} \sum_{t=1}^{T} \hat{S}_{i,t}^2) \tag{3}$$

[2] Apart from these two testing procedures, we also employ a battery of the first generation test. Since they are widely used in the literature, we skip the explanation of the first generation tests.

where $\hat{S}_{i,t}^2 = \sum_{j=1}^{t} \hat{\varepsilon}_{i,j}$ denotes the partial sum process that is obtained using the estimated OLS residuals of (1). The $\hat{\omega}_i^2$ is a consistent estimate of the long-run variance of $\varepsilon_{i,t}, \omega_i^2 = \lim_{T\to\infty} T^{-1} E(S_{i,T}^2)$, i = 1,…….,N, which allows the disturbances to be heteroscedastic across the cross-sectional dimension. λ in (3) indicates the dependence of the test on the dates of the break. For each individual *i*, it is defined as the vector $\lambda_i = (\lambda_{i,1,.....,}\lambda_{i,m_i})' = (T_{b,1}^i / T, ..., T_{b,m_i}^i / T)'$ indicates the relative positions of the dates of the breaks in the whole time period. In addition, to detect the numbers of break in each individual time series, Carrion-i-Silvestre *et al.* (2005) employ the procedure of Bai and Perron (1998) which allows each individual unit to have a different number of breaks with heterogenous break location across unit. After determining the vector λ_i, the test statistics for the null hypothesis of a stationary panel with multiple shifts is defined as:

$$Z(\lambda) = \frac{\sqrt{N}(LM(\lambda) - \bar{\xi})}{\zeta} \to N(0,1) \tag{4}$$

where $\bar{\xi}$ and ζ^2 are computed as averages of individual and means and variances of $LM(\lambda)$ and it has standard normal distribution.

It should be noted that the above test statistic assumes that individuals are cross sectionally independent. However, this assumption is clearly unrealistic in a globalised economy where the shocks overpass the borders of the economies. In order to accommodate for cross-section dependence of the test statistic, Carrion-i-Silvestre *et al.* (2005) suggested computing the bootstrap distribution following a procedure proposed by Maddala and Wu (1999).

Im *et al.* (2005) propose a panel LM unit root test that is robust to structural shifts. The test begins with the computation of univariate LM unit root test statistics for each series. Then, the panel LM test statistics is obtained by averaging the optimal univariate LM unit root t-test statistics (LM_i^{τ}). Specifically, the panel LM test is defined as:

$$LM_{barNT} = \frac{1}{N}\sum_{i=1}^{N} LM_i^{\tau} \tag{5}$$

In addition, Im *et al.* (2005) construct a standardized panel LM unit root test statistics by letting $E(L_T)$ and $V(L_T)$ to define as the expected value and variance of LM_i^{τ} respectively under the null hypothesis. Then, the standardized test statistic is given by:

$$\psi_{LM} = \frac{\sqrt{N}(LM_{barNT} - E(L_T))}{\sqrt{V(L_T)}} \tag{6}$$

The numerical values for $E(L_T)$ and $V(L_T)$ are in Im *et al.* (2005) and the asymptotic distribution is unaffected by the presence of structural breaks and it is standard normal.

3. Empirical results

The data used in this paper are obtained from the International Finance Corporation's Emerging Market Database (IFC-EMDB). The U.S. dollar-denominated stock price indices are from 1985 to 2006 covering 15 emerging markets. The sampled countries are Argentina, Brazil, Chile, Colombia, India, Jordan, South Korea, Malaysia, Mexico, Nigeria, Pakistan, Philippines, Taiwan, Thailand, and Zimbabwe. All stock prices are transformed into natural logarithmic form prior to the analysis.

We argue that the assumption of cross-sectional dependence is likely to hold in this analysis. One way of testing the appropriateness of this assumption is to apply the LM test developed by Breusch and Pagan (1980).[3] The test for the hypothesis that all correlation coefficients are jointly 0 is defined as $\lambda_{LM} = T\sum_{i=1}^{N}\sum_{j=1}^{i-1} r_{ij}^2$ where T is number of time series observation, N is number of countries, and r_{ij}^2 is the ij th residual correlation coefficient, distributed as χ^2 with $N(N-1)/2$ degree of freedom under the null of no cross section dependence. The hypothesis of cross sectional independence is tested on the residuals of individual series obtained by running OLS regression of each series on its own lag and deterministic components (intercept and time trend). The test statistics show strong evidence of cross-section dependence as the null of no cross-section dependence can be rejected at the 5% level of significance (*LM* statistic: 697.48; *p*-value: 0.000).

Next, we proceed to testing the stationarity of stock prices. We first apply a battery of the first generation panel unit root tests without breaks which include unit root tests by Levin *et al.* (2002) and Im *et al.* (2003) and the panel stationarity test due to Hadri (2000). Results are presented in Table 1. Based on the Levin *et al.* (2002) and Im *et al.* (2003) test results, we could not find any evidence that support mean reversion hypothesis as the null of unit root cannot be rejected in both cases at the usual level. Consistent with the previous finding, the result of Hadri (2000) panel stationarity test reveals that the null of mean reversion can be rejected at the 5 percent level.

[3] Breusch and Pagan (1980) test is more appropriate for our sample since the cross section dimension (N) is small relative to the time dimension (T). In the case of small T and large N, one may consider Pesaran *et al.* (2008) testing procedure. We thank the referee for the suggestion.

Table 1: The first generation panel unit root tests

	Test statistics	***p*-value**
Levin, Lin and Chu (2002)	0.426	0.665
Im, Pesaran and Shin (2003)	-2.153	0.357
Hadri (2000)	13.886	0.000*

Notes: * denotes rejection of null at the 5 percent level.

It should be emphasized however that the first generation panel unit root tests above tend to under reject the null for not taking into account the existence of structural changes in the underlying series. Failure to consider any possible break points in the series may lead to a misleading interpretation of stationarity with structural break(s) as a unit root. A number of studies have linked stock markets to major economic crises, such as the Asian Financial Crisis in 1997 and the October 1987 market crash, and also to stock market liberalization. Moreover, the first generation tests ignore the cross sectional dependence which was shown to be relevant for this study. However, ignoring cross sectional dependence in unit root or stationarity test may lead to incorrect inferences.

In order to get a better insight on the present issue, the next logical step is to examine the properties of stock prices using a panel test that allows for the presence of structural changes and simultaneously control for cross section dependence. We apply the panel stationarity test developed by Carrion-i-Silvestre *et al.* (2005) to our dataset and account for cross-section dependence of the stock prices by computing critical values using a bootstrap procedure following Maddala and Wu (1999).[4] Apart from conducting the panel test of stationarity for all countries, we also examine a panel of Asian countries.[5] Our results are based on the assumption that the long-run variance is homogenous and heterogeneous. Under each of these assumptions, we conduct panel tests by allowing for a maximum of five structural breaks selected using the modified Schwarz information criterion (LWZ) of Liu *et al.* (1997).

The results of these exercises are reported in Table 2. As shown in the table, the analysis for the overall sample strongly indicates rejection of the null of stationary irrespective of whether the long-run variance is homogenous or heterogeneous. Also, the results for the Asian sub-sample indicate that the null can be rejected at the usual level of significance. These findings strongly suggest that stock prices in emerging markets can be characterized as a random walk (unit root) process. This finding which is consistent with the efficient market hypothesis suggests that stock prices instantaneously respond to all relevant information in the market.

[4] Interested readers may refer to Maddala and Wu (1999) and Carrion-i-Silvestre *et al.* (2005) for the details of the bootstrap procedure.

[5] We would like to analyze a panel of Latin American countries but data limitation impedes the implementation of the analysis.

Table 2: Panel stationarity test due to Carrion-i-Silvestre *et al.* (2005)

	Test statistics	**Critical values**		
		10%	5%	1%
Overall sample:				
Homogeneous	82.02 *	23.13	24.50	27.89
Heterogeneous	256.43 *	56.27	66.27	80.30
Asian region:				
Homogeneous	51.49 *	24.22	28.17	35.53
Heterogeneous	329.24 *	61.71	73.21	105.57

Notes: * denotes rejection of null at the 5 percent level. The maximum numbers of structural breaks is 5 and were selected using the modified Schwarz information criterion (LWZ) of Liu *et al.* (1997). The critical values were computed using bootstrap distribution technique with 2000 replications.

A limitation of the above testing procedure is that the rejection of null does not implies that all stock prices contain unit root. Instead, it only indicates that stock prices in some countries may have unit root. However, the test is not able to point out which stock prices are really non-stationary. To address this problem, we complement the above findings with the results of unit root testing of Im *et al.* (2005) which allow us to check the stochastic properties of individual series. Two models were estimated namely, Model A that allows breaks in intercept, and Model C that allows breaks in both intercept and trend. Results are presented in Table 3. As shown in the table, results for Model A reveal that the null of unit root can be rejected at the 5 percent level in the case of Argentina, Chile, Mexico, Nigeria, Pakistan, Philippines, Taiwan, Thailand, and Zimbabwe. This result suggests that efficient market hypothesis only hold in four countries namely Brazil, Colombia, India and Jordan. Meanwhile, for Model C the null can be rejected at the usual level except for Brazil, Colombia, and South Korea. By and large, the results reveal that the majority of the stock prices can be characterized as a mean reverting process, implying that future prices can be predicted using historical prices. This finding is consistent with Chaudhuri and Wu (2003) who find mean reverting behavior of stock prices in ten emerging markets.

Table 3: Panel unit root test due to Im *et al.* (2005)

Country	Model A	lag	Model C	lag
Argentina	-4.1224*	0	-7.2998*	0
Brazil	-3.1906	4	-5.4969**	5
Chile	-4.3461*	0	-6.1787*	6
Colombia	-2.9228	0	-4.7981	6
India	-2.8231	6	-10.0366*	5
Jordan	-3.7679**	6	-11.0742*	6
South Korea	-3.1162	0	-4.5030	5
Malaysia	-2.8768	6	-10.7457*	6
Mexico	-4.3558*	0	-10.0035*	6
Nigeria	-5.9111*	0	-6.2044*	0
Pakistan	-4.8817*	0	-7.5262*	6
Philippines	-5.1787*	0	-5.8042*	6
Taiwan	-6.0107*	0	-5.2174*	0
Thailand	-5.5888*	5	-5.8823*	0
Zimbabwe	-4.0017*	6	-6.7327*	4
Panel LM test statistics		-29.044*		

Notes: * and ** denotes the rejection of null at the 5 and 10 percent level, respectively. The critical values for the univariate LM statistics for model A are -3.842 (5% level) and -3.504 (10% level). The critical values for model C are -5.73 (5% level) and -5.32 (10% level). The corresponding critical values for the panel LM statistics are -1.645 and -1.282.

4. Conclusions

In this paper, we re-examined the validity of efficient market hypothesis in 15 emerging stock markets by applying a new panel stationarity developed test by Carrion-i-Silvestre *et al.* (2005) which is flexible enough to accommodate multiple breaks. A preliminary analysis on stock prices shows that they are cross-sectionally dependent. Since the test by Carrion-i-Silvestre *et al.* (2005) is not able to account for cross sectional dependence, we compute the critical values of the test statistics via a bootstrap-based method as suggested by Maddala and Wu (1999). In so doing, we managed to account for the stock price dependence. The result shows that the stock prices follow a random walk process, lending support to the efficient market hypothesis. However, further evidence based on the Im *et al.* (2005) testing procedure show that the majority of stock prices in emerging markets are mean reverting.

References

Bai, J. and Perron, P. (1998) "Estimating and testing linear models with multiple structural changes" *Econometrica* **66**, 47–78.

Bekaert, G., Harvey, C. and Lumsdaine, R. (2002) "Dating the integration of world equity markets" *Journal of Financial Economics* **65**, 203-247.

Breusch, T. S. and Pagan, A. R. (1980) "The Lagrange Multiplier Test and Its Applications to Model Specification in Econometrics" *Review of Economic Studies* **47**, 239-53.

Carrion-i-Silvestre, J. L., Del Barrio, T. and Lopez-Bazo, E. (2005) "Breaking the panels: an application to the GDP per capita" *Econometrics Journal* **8**, 159-175.

Chaudhuri, K. and Wu, Y. (2003) “Random walk versus breaking trend in stock process: evidence from emerging markets” *Journal of Banking and Finance* **27**, 575-592.

Chen, G., Firth, M. and Rui, O. M. (2002) “Stock market linkages: evidence from Latin America” *Journal of Banking and Finance* **26**, 1133-1141.

Hadri, K. (2000) “Testing for stationarity in heterogeneous panel data” *Econometrics Journal* **3**, 148-161.

Henry, P. B. (2000) “Stock market liberalization, economic reform and emerging market equity prices” *Journal of Finance* **55**, 529-564.

Im, K. S., Lee, J. and Tieslau, M. (2005) “Panel LM unit root tests with level shifts” *Oxford Bulletin of Economics and Statistics* **67**, 393-419.

Im, K. S., Pesaran, M. H. and Shin, Y. (2003) “Testing for unit roots in heterogeneous panels” *Journal of Econometrics* **115**, 53-74.

Levin, A., Lin, C. F. and Chu, J. C. S. (2002) “Unit root tests in panel data: asymptotic and finite-sample properties” *Journal of Econometrics* **108**, 1-24.

Liu, J., Wu, S. and J. V. Zidek (1997) “On segmented multivariate regressions” *Statistica Sinica* **7**, 497–525.

Maddala, G. S. and Wu, S. (1999) “A comparative study of unit root tests with panel data and a new simple test” *Oxford Bulletin of Economics and Statistics* **61**, 631-652.

Narayan, P. K. (2008) “Do shocks to G7 stock prices have a permanent effect? Evidence from panel unit root tests with structural change” *Mathematics and Computers in Simulation* **77**, 369-373.

Perron, P. (1989) “The Great Crash, the oil price shock and the unit root hypothesis” *Econometrica* **55**, 277-302.

Pesaran, M. H., Ullah, A. and Yamagata, T. (2008) “A bias adjusted LM test of error cross-section independence” *Econometrics Journal* **11**, 105-117.

Phengpis, C. (2006) “Are emerging stock markets price indices really stationary?” *Applied Financial Economics* **16**, 931-939.

Ratanapakorn, O. and Sharma, S.C. (2002) “Interrelationships among regional stock indices” *Review of Financial Economics* **11**, 91-108.