SCHOOL OF ECONOMICS

Discussion Paper 2003-05

The Random Walk Behaviour of Stock Prices: A Comparative Study

Arusha Cooray

ISSN 1443-8593
ISBN 1 86295 130 6

The Random Walk Behaviour of Stock Prices: A Comparative Study

Arusha Cooray*

Abstract:

This paper tests the random walk hypothesis for the stock markets of the US, Japan, Germany, the UK, Hong Kong and Australia using unit root tests and spectral analysis. The results based upon the augmented Dicky Fuller (1979) and Phillips-Perron (1988) tests and spectral analysis find that all markets exhibit a random walk. The multivariate cointegration tests based upon the Johansen Juselius (1988, 1990) methodology indicates that all six markets share a common long run stochastic trend. The vector error correction models suggest a short run relationship between the US, Germany, Australia and the rest of the markets implying that these countries can gain in the short run by diversifying their portfolios.

* Corresponding author: Arusha Cooray, School of Economics, University of Tasmania, Private Bag 85, Hobart Tasmania 7001, Australia. Tel: 61-3-6226-2821; Fax: 61-3-6226-7587; E-mail: arusha.cooray@utas.edu.au

1 Introduction

This study tests the random walk hypothesis for the stock markets of the US, Japan, Germany, UK, Hong Kong and Australia employing stock market indices. The random-walk hypothesis asserts that successive price changes are identically distributed independent random variables. In an efficient market, the information contained in past prices is fully and instantaneously reflected in current prices. Hence, the opportunity for any abnormal gain on the basis of the information contained in historical prices is eliminated. Market efficiency would then imply that successive price changes are independent. Most of the early studies supported the random-walk behaviour of stock prices: Kendall (1953), Roberts (1959), Alexander (1961), Cootner (1964) and Fama (1965), among many others.

Recent studies on stock markets reject the random walk behaviour of stock prices - Lo, MacKinlay, Craig (1997), Taylor (200). Similarly Gallagher and Taylor (2002) show that stock prices are not pure random walks. This study on the contrary supports the random walk hypothesis. The random walk hypothesis is tested using the ADF (1979) and Phillips Perron (1988) unit root tests and spectral analysis. If the unit root tests indicate that the series are nonstationary, then they are said to follow a random walk. An alternative approach to testing for weak form efficiency is spectral analysis which is a method of testing for oscillatory movements in a time series. This enables identifying any cyclical or seasonal patterns in stock prices. The random walk hypothesis claims that there are no cyclical patterns in stock prices.

2 Data

The data set consists of stock market indices for the US, Japan, Germany, UK, Hong Kong and Australia. The data used is monthly and covers the period 1991.4 to 2003.2. All data series are obtained from DATASTREAM. In order to obtain a better understanding of the data, Table 1 presents a summary of the logarithms of the first differences of the stock prices indices.

Table 1: Statistics of the First Differences of the Stock Price Indices

	US Dow Jones	Japan Nikkei	Germany DAX	Britain FTSE 100	Hong Kong Hang Seng	Australia All Ordinaries
Maximum	.10084	.15001	.41542	.10190	.26449	.078443
Minimum	-.16412	-.18317	-.29327	-.21268	-.32822	-.11572
Mean	.00696	-.0080	.0045	-.0025	.0062	.0046
Std Deviation	.04437	.0624	.0744	.0511	.0846	.0371
Skewness	-.6656	-.06804	.39279	-.96874	-.07323	-.31270
Kurtosis-3	1.2775	-.31012	7.1779	1.7052	2.0095	-.00854
Coef of Variation	6.3691	7.7983	16.2546	19.9314	13.5928	8.0240

The data suggest that the means of the first differences for the Dow Jones, DAX, Hang Seng, and the All Ordinaries are not far apart. For the Nikkei and FTSE 100 the means are negative. The standard deviation of all the stock indices appear to move closely together. The first differences of the Dow Jones, Nikkei, FTSE 100, Hang Seng and the All Ordinaries appear to be skewed to the left while the DAX is skewed to the right. The kurtosis for the DAX is greater than 3 which is the kurtosis of a normal distribution. For the rest of the stock indices it is less than 3. The coefficient of variation indicates that price changes have been relatively more variable in Germany, the UK and Hong Kong than in the US, Japan and Australia. Table 2 presents the pairwise co-movements among the changes in stock prices. All the correlation coefficients are positive and in the range of 0.28 and 0.71.

Table 2: Estimated Correlation Matrix of Variables of Stock Price Changes

	Dow Jones	Nikkei	DAX	FTSE 100	Hang Seng	All Ords
Dow Jones	1.0000	.39675	.60792	.70960	.60394	.59694
Nikkei	.39675	1.000	.34998	.28549	.29215	.46973
DAX	.60792	.34998	1.0000	.64228	.38206	.49675
FTSE 100	.70960	.28549	.64228	1.0000	.50459	.56533
Hang Seng	.60394	.29215	.38206	.50459	1.0000	.58256
All Ords	.59694	.46973	.49675	.56533	.58256	1.0000

3 Methodology

The random walk hypothesis is tested using unit root tests and spectral analysis. Both the augmented Dicky Fuller test and Phillips-Perron (1987, 1988) tests based upon equations (1) and (2) are carried out to examine the univariate time series properties of the data to see if the random walk hypothesis holds. The Augmented Dickey Fuller (ADF) unit root test is based on the estimation of the following equation:

$$\Delta X_t = \beta_0 + \beta_1 X_{t-1} + \beta_2 T + \sum_{i=1}^{n} \beta_i \Delta X_{t-i} + \varepsilon_t \quad (1)$$

where X_t = the time series; T = linear time trend; ε_t = the error term with zero mean and constant variance. The null hypothesis of a unit root $\beta_1 = 0;$ is tested against the alternative hypothesis, $\beta_1 < 0$. The Z_t statistic put forward by Phillips and Perron (1987, 1988) is a modification of the Dickey-Fuller *t* statistic which allows for autocorrelation and conditional heteroscedasticity in the error term of the Dicky-Fuller regression. This is based on the estimation of the following:

$$X_t = \alpha_0 + \alpha_1(t-T/2) + \alpha_2 X_{t-1} \quad \varpi_t \quad (2)$$

Cointegration

The Johansen (1988) and Johansen and Juselius (1990) procedure is employed to test for a long-run relationship between the variables. Johansen and Juselius propose a maximum likelihood estimation approach for the estimation and evaluation of multiple cointegrated vectors. Johansen and Juselius (1990) consider the following model:

Let X_t be an nx1 vector of I(1) variables, with a vector autoregressive (VAR) representation of order k,

$$X_t = \Pi_1 X_{t-1} + \ldots. + \Pi_k X_{t-k} + \upsilon + e_t \qquad (3)$$

$$t = 1, 2, \ldots. T$$

where υ is an intercept vector and e_t is a vector of Gaussian error terms.

In first difference form equation (3) takes the following form,

$$\Delta X_t = \Gamma_{k-1} \Delta X_{t-k+1} + \ldots. + \Pi X_{t-k} + \upsilon + e_t \qquad (4)$$

where

$\Gamma_i = - (I - \Pi_1 - \ldots \Pi_i)$, *for* $i= 1, \ldots.. , k-1$

and

$\Pi = - (I - \Pi_1 - \ldots\ldots - \Pi_k)$

Π is an nxn matrix whose rank determines the number of cointegrating vectors among the variables in X. If matrix Π is of zero rank, the variables in X_t are integrated of order one or a higher order, implying the absence of a cointegrating relationship between the variables in X_t. If Π is full rank, that is, r = n, the variables in X_t are stationary; and if Π is of reduced rank,

$0 < r < n$, Π can be expressed as $\Pi = \alpha\beta'$ where α and β are nxr matrices, with r the number of cointegrating vectors. Hence, although X_t itself is not stationary, the linear combination given by $\beta'X$ is stationary.

Johansen and Juselius propose two likelihood ratio tests for the determination of the number of cointegrated vectors. One is the maximal eigenvalue test which evaluates the null hypothesis that there are at most r cointegrating vectors against the alternative of r + 1 cointegrating vectors. The maximum eigenvalue statistic is given by,

$$\lambda_{max} = - T \ln (1 - \lambda r+1) \qquad (5)$$

where λ r+1,…,λn are the n-r smallest squared canonical correlations and T = the number of observations.

The second test is based on the trace statistic which tests the null hypothesis of r cointegrating vectors against the alternative of r or more cointegrating vectors. This statistic is given by

$$\lambda_{trace} = -T \Sigma \ln (1 - \lambda i) \qquad (6)$$

In order to apply the Johansen procedure, a lag length must be selected for the VAR. A lag length of one is selected on the basis of the Akaike Information Criterion (AIC).[1]

Spectral Analysis

Spectral analysis is the study of time series in the frequency domain. The purpose of this analysis is to determine if the stock prices exhibit any systematic cyclical variation. The sample spectrum

---

[1] The AIC is computed as: $AIC(k) = \ln|\Sigma_k| + (2 p^2 k)/n$, where Σ is the residual covariance matrix; p, the number of variables in the system; n, the number of observations and k the order of lag in the VAR.

is the Fourier Cosine transformation of the estimate of the autocovarience function. The Fourier series is a representation of a function as a sum of harmonic terms such that;

$$f(x) = \sum_{\alpha=1}^{\infty} a_\alpha \sin \alpha x + 1/2\, a_0 + \sum_{\alpha=1}^{\infty} b_\alpha \cos \alpha x$$

$$\text{or} \quad a_0/2 + \sum_{\alpha=1}^{\infty} c_\alpha \sin(\alpha x + \delta),$$

where δ = time lag and α = amplitude of price changes.

If δ is measured in radians per unit of time, sin αx repeats itself with period $2\pi/\alpha$ and therefore the number of cycles per unit or frequency is $\alpha/2\pi$. The period $2\pi/\alpha$ is a dimension of t. Spectral analysis permits the identification of any cyclical components in a data series. The angular frequency measured in radians per unit is represented by $2\pi/\alpha$. If p_t, the price series, contains a periodic element of period k and therefore the frequency, $2\pi/k$, the spectral densities will have a sharp spike at $\alpha = \alpha_k$. If the filtered p_t does not contain any periodicities, the spectral densities will be smooth.

The spectral densities of the logarithms of the prices and their first differences are estimated for 150 lags. The spectral densities are estimated as follows:

$$F(\varpi_j) = 1/2\pi\, [\lambda_0 C_0 + 2 \sum_{K=0}^{\infty} \lambda_k C_k \cos \varpi_j k\,]$$

$\varpi_j = \pi j/m$ = j = 0, 1, 2, ….m, where m = 150 lags.

The estimated autocovariance is given by,

$$C_k = 1/\text{n-k}\, [\sum_{t=1}^{n-k} p_t p_{t+k} - 1/\text{n-k} \sum_{t=1+k}^{n} p_t \sum_{t=1}^{n-k} p_t\,]$$

With data, p_t, t = 1,…,n and the weights, λ_k are dependent upon m. Microfit computes the Bartlett, Tukey and Parzen estimates.

4 Empirical Results

Table 3 presents the time series properties of the data.

Unit Root Tests

Table 3: ADF and Phillips Unit Root Tests

Variable	Log ADF	Levels PP	Log First ADF	Differences PP
US Dow Jones	-1.53	-2.05	-13.16***	-15.04***
Japanese Nikke	-0.75	-0.86	-12.12***	-17.76***
German	-1.98	-1.22	-11.09***	-13.63***
London FT	-0.29	-0.28	-10.17***	-13.71***
Hong Kong	-2.68	-3.17	-11.73***	-15.29***
Australia All-Ord	-1.59	-1.71	-13.77***	-14.58***

Note: The lag length for the ADF and Phillip-Perron regressions has been selected to ensure white noise residuals. A fourth order autoregressive model is used for the ADF test on the basis of the AIC and ten lags on the Bartlett window are used for the Phillip test.

Significance levels with trend: 1%, -4.07 : 5%, -3.46 : 10% -3.16; without trend: 1%, -3.51 : 5%, -2.90, 10% -2.58 (Davidson and MacKinnon 1993).

*, **, *** significant at the 10%, 5% and 1% levels respectively.

Table 3 suggests that all stock market indices are I(1) confirming the random walk hypothesis of stock market prices and I(0) in the first differences.

Cointegration Tests

Table 4: Johansen-Juselius Maximum Likelihood Cointegration Test

Null	Alternative	*Dow Jones-Nikkei* mλ	Trace	95% mλ	critical value Trace
r = 0	r = 1	18.86	20.75	15.87	20.18
r < = 1	r = 2	1.89	1.90	9.16	9.16
		Dow Jones-DAX			
r = 0	r = 1	10.47	15.71	15.87	20.18
r < = 1	r = 2	5.24	5.24	9.16	9.16
		Dow Jones- FTSE 100			
r = 0	r = 1	16.84	29.40	15.87	20.18
r < = 1	r = 2	12.56	12.56	9.16	9.16
		Dow Jones-Hang Seng			
r = 0	r = 1	9.15	16.81	15.87	20.18
r < = 1	r = 2	7.64	7.64	9.16	9.16
		Dow Jones-All Ordinaries			
r = 0	r = 1	15.11	18.37	15.87	20.18
r < = 1	r = 2	3.26	3.26	9.16	9.16
		Nikkei-DAX			
r = 0	r = 1	11.46	13.83	15.87	20.18
r < = 1	r = 2	2.36	2.36	9.16	9.16
		Nikkei-FTSE 100			
r = 0	r = 1	15.39	17.24	15.87	20.18
r < = 1	r = 2	1.86	1.86	9.16	9.16
		Nikkei-Hang Seng			
r = 0	r = 1	13.18	16.49	15.87	20.18
r < = 1	r = 2	3.30	3.30	9.16	9.16
		Nikkei-All Ordinaries			
r = 0	r = 1	13.76	17.10	15.87	20.18
r < = 1	r = 2	3.33	3.33	9.16	9.16
		DAX-FTSE 100			
r = 0	r = 1	19.78	25.31	15.87	20.18
r < = 1	r = 2	5.52	5.52	9.16	9.16
		DAX-Hang Seng			
r = 0	r = 1	9.94	15.16	15.87	20.18
r < =	r = 2	5.22	5.22	9.16	9.16
		DAX-All Ordinaries			
r = 0	r = 1	8.39	10.50	15.87	20.18
r < = 1	r = 2	2.10	2.10	9.16	9.16

Table 4: Continued

		FTSE 100-Hang Seng Kong			
r = 0	r = 1	11.43	12.66	15.87	20.18
r < = 1	r = 2	1.23	1.23	9.16	9.16
		FTSE 100-All Ordinaries			
r = 0	r = 1	18.86	25.11	15.87	20.18
r < = 1	r = 2	6.25	6.25	9.16	9.16
		All Ordinaries-Hang Seng			
r = 0	r = 1	8.74	16.03	15.87	20.18
r < = 1	r = 2	7.28	7.28	9.16	9.16
		All			
r = 0	r = 1	42.43	117.36	40.53	102.56
r < = 1	r = 2	30.18	74.92	34.40	75.98
r < = 2	r = 3	18.48	44.74	28.27	53.48
r < = 3	r = 4	12.89	26.25	22.04	34.87
r < = 4	r = 5	8.93	13.36	15.87	20.18
r < = 5	r = 6	4.42	4.42	9.16	9.16

The cointegration tests presented in Table 4 indicate an unique cointegrating vector for three out of the 14 bivariate models, the Dow-Jones-FTSE 100, Dow Jones-Nikkei, DAX-FTSE 100 and FTSE 100-All Ordinaries. There is an unique cointegrating vector for all the stock markets. Hence the results suggest that all the markets share a common stochastic trend and departures from this will be temporary.

Presented below are the error correction models for the markets that are cointegrated.

Bivariate Error Correction Models

Dow Jones-FTSE 100

ΔDJ_t = - 0.14 ΔDJ_{t-1} + 0.10$\Delta FTSE_{t-1}$ - 0.002EC_{t-1}

(-1.07) (0.81) (0.23)

$\chi^2_{sc} = 16.77$ $\chi^2_{ff} = 2.44$ $\chi^2_{n} = 16.05$ $\chi^2_{hs} = 0.01$

$\Delta FTSE_t$ = 0.03 $\Delta FTSE_{t-1}$ + 0.08ΔDJ_{t-1} - 0.05EC_{t-1}

(0.21) (0.56) (2.60)

$\chi^2_{sc} = 10.61$ $\chi^2_{ff} = 1.86$ $\chi^2_{n} = 25.43$ $\chi^2_{hs} = 2.33$

Dow Jones-Nikkei

$\Delta DJ_t = -0.13\ \Delta DJ_{t-1} - 0.04\Delta NIKKEI_{t-1} - 0.01EC_{t-1}$

(-1.37) (0.57) (2.5)

$\chi^2_{sc} = 12.13 \quad \chi^2_{ff} = 1.08 \quad \chi^2_{n} = 27.62 \quad \chi^2_{hs} = 0.15$

$\Delta NIKKEI_t = 0.01\ \Delta NIKKEI_{t-1} - 0.05\Delta DJ_{t-1} - 0.05EC_{t-1}$

(0.05) (0.37) (-2.05)

$\chi^2_{sc} = 7.3 \quad \chi^2_{ff} = 0.03 \quad \chi^2_{n} = 1.2 \quad \chi^2_{hs} = 0.41$

DAX-FTSE 100

$\Delta FTSE_t = -0.10\ \Delta FTSE_{t-1} + 0.06\Delta DAX_{t-1} - 0.14EC_{t-1}$

(0.82) (0.77) (4.14)

$\chi^2_{sc} = 7.75 \quad \chi^2_{ff} = 0.43 \quad \chi^2_{n} = 35.41 \quad \chi^2_{hs} = 0.11$

$\Delta DAX_t = 0.09\ \Delta DAX_{t-1} - 0.28\Delta FTSE_{t-1} - 0.08EC_{t-1}$

(0.83) (-1.53) (-3.76)

$\chi^2_{sc} = 12.53 \quad \chi^2_{ff} = 6.69 \quad \chi^2_{n} = 35.41 \quad \chi^2_{hs} = 4.58$

FTSE 100-All Ordinaries

$\Delta FTSE_t = 0.02\ \Delta FTSE_{t-1} - 0.09\Delta ALLORD_{t-1} - 0.10EC_{t-1}$

(0.22) (-0.67) (4.23)

$\chi^2_{sc} = 7.75 \quad \chi^2_{ff} = 0.43 \quad \chi^2_{n} = 35.41 \quad \chi^2_{hs} = 0.11$

$\Delta ALLORD_t = -0.14\ \Delta ALLORD_{t-1} - 0.02\Delta FTSE_{t-1} - 0.07EC_{t-1}$

(-1.29) (-0.23) (-2.96)

$\chi^2_{sc} = 15.02 \quad \chi^2_{ff} = 0.01 \quad \chi^2_{n} = 2.54 \quad \chi^2_{hs} = 0.01$

The error correction term is of the correct sign for all the models. The error correction terms in the Dow Jones-Nikkei, DAX-FTSE 100, FTSE 100-All Ordinaries models are significant, suggesting a stable long run relationship between these markets. The error correction term for the USDJ-FTSE 100 however is not statistically significant. The diagnostic tests for serial correlation, functional form misspecification, and heteroscedasticity suggest that the models are well-specified. The χ^2 statistics for serial correlation in the models are to be compared with the critical value of 21.03, with 12 degrees of freedom. Ramsey's (1969) RESET test statistics for functional form misspecification are to be compared with the 5% critical value of 3.84. It is observed that the models are well specified. The Jarque-Bera (1980) test for the normality of residuals indicates a non-normal distribution for the disturbance terms in all equations. This is consistent with the distribution functions for financial assets. See Enders (2004). All equations, support the assumption of homoscedasticity on the basis of a LM test.

Table 5: Vector Error Correction Models

Dependent Variable	ΔDJ_{t-1}	$\Delta NIKKEI_{t-1}$	Δ $FTSE_{t-1}$	ΔDAX_{t-1}	ΔHS_{t-1}	$ALLORDS_{t-1}$	EC_{t-1}
ΔDJ_t	-0.51	-0.20	0.20	0.06	0.16	-0.23	-0.08
	-(3.15)	(-0.20)	(1.50)	(0.72)	(2.41)	(-1.26)	(3.50)
$\Delta FTSE_t$	-0.12	0.03	0.25	0.07	0.07	-0.41	-0.04
	(-0.60)	(0.28)	(1.50)	(0.73)	(0.92)	(-1.90)	(1.49)
$\Delta NIKKEI_t$	0.34	0.07	0.42	0.04	0.08	-0.51	-0.02
	(-1.45)	(0.62)	(2.19)	(0.34)	(0.86)	(-1.97)	(0.69)
ΔDAX_t	-0.39	-0.09	0.19	0.08	0.06	-0.17	-0.16
	(-1.43)	(-0.71)	(0.08)	(0.61)	(0.51)	(-0.58)	(4.18)
ΔHS_t	-0.53	0.08	0.15	0.05	0.14	-0.31	-0.09
	(-1.66)	(0.49)	(0.58)	(0.32)	(1.09)	(-0.86)	(1.95)
$\Delta ALLORD_t$	-0.23	-0.01	0.22	-0.01	0.11	-0.41	-0.06
	(-1.77)	(-0.12)	(2.06)	(-0.08)	(2.12)	(-2.28)	(3.41)

t statistics reported in parenthesis

Since there is an unique cointegrating vector in the six variable VAR, the short run dynamics of the stock markets are also examined using a VECM. See Table 5. The error correction terms for the Dow Jones, the DAX and All Ordinaries are statistically significant suggesting a short run relationship between these markets and the rest of the stock markets.

Spectral Analysis

The spectral densities are estimated for the logs of the series and the first differences of the logs of the series. Figures 1-6 give the spectral density functions for the logs of the indices using the Bartlett, Tukey and Parzen lag windows. These series appear to confirm the random walk hypothesis of stock prices. Due to the non stationarity of the data, the spectral density is controlled by the value at the zero frequency. The spectral densities are estimated for the first differences of the series (see Figures 7-12). The first differences of the series appear to confirm the results obtained in Table 3 that the series are I(0) in the first differences.

Figure 1

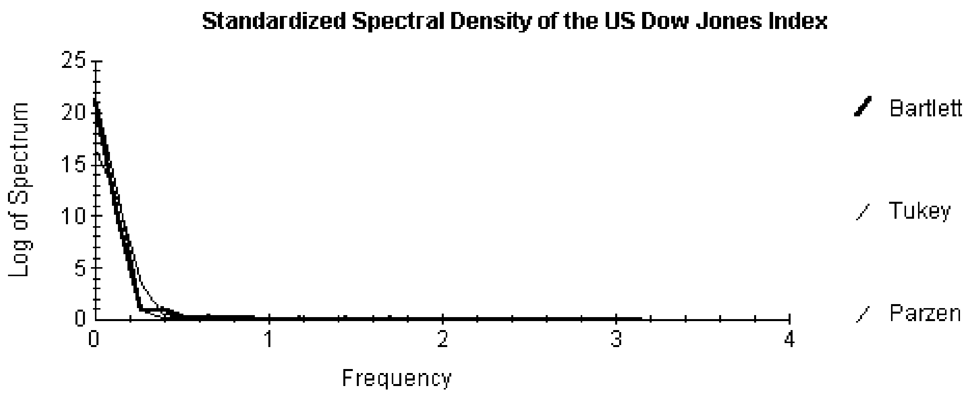


Figure 2

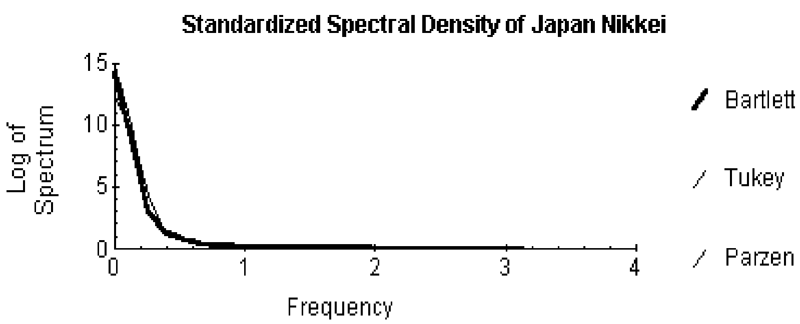


Figure 3

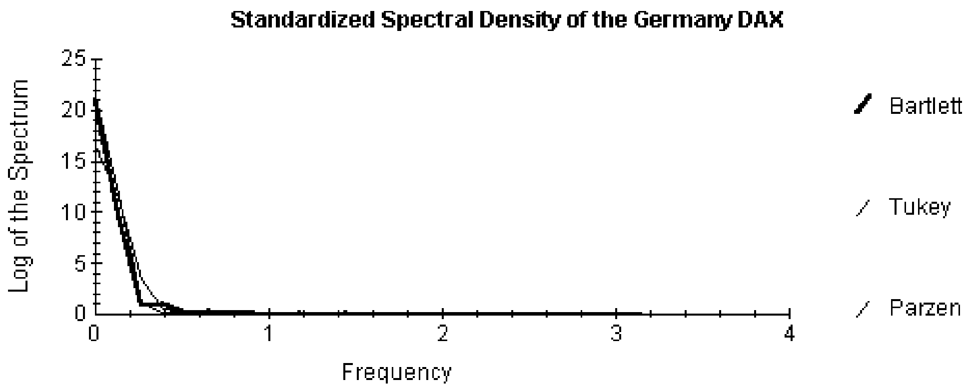


Figure 4

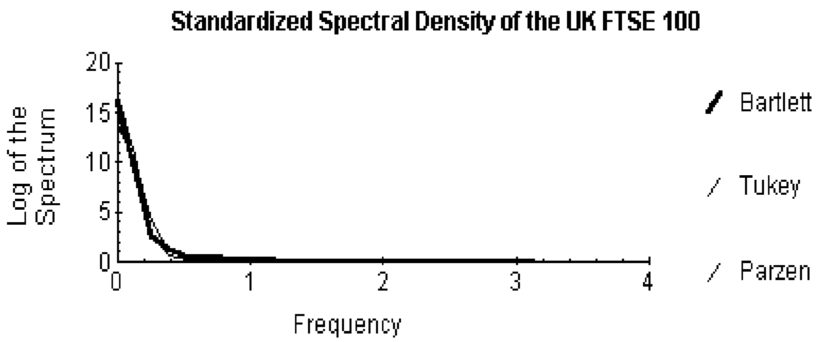


Figure 5

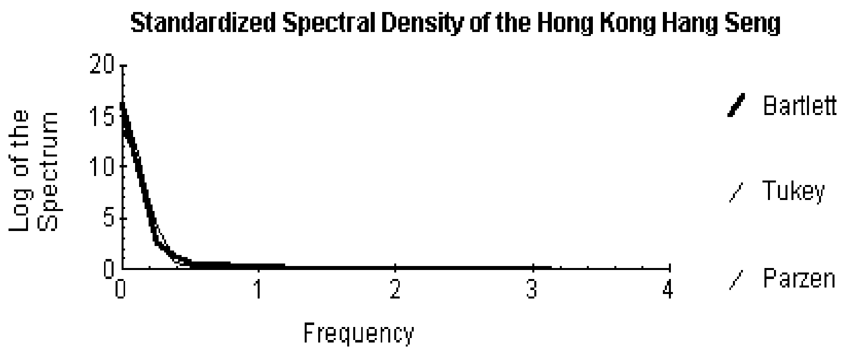
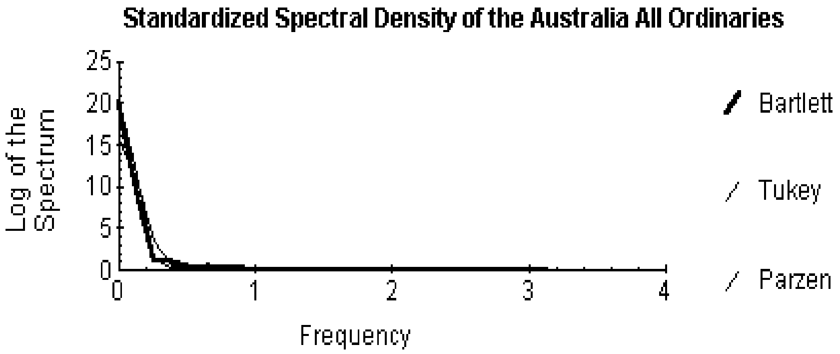


Figure 6



Standardized Spectral Density Functions of the First Differences of the Stock Price Indices

Figure 7

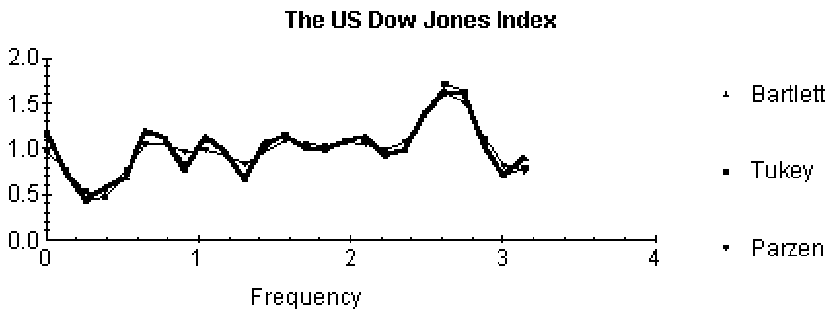


Figure 8

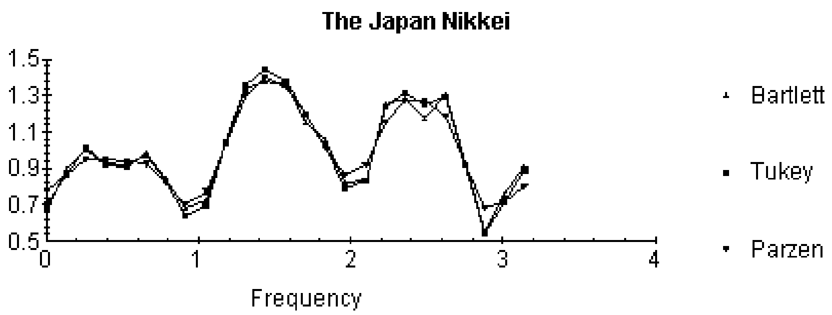


Figure 9

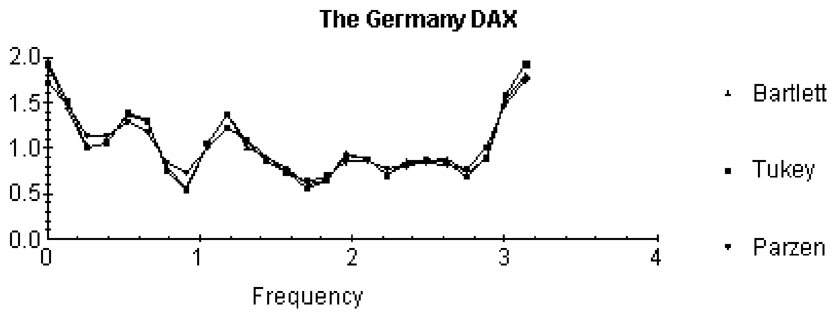


Figure 10

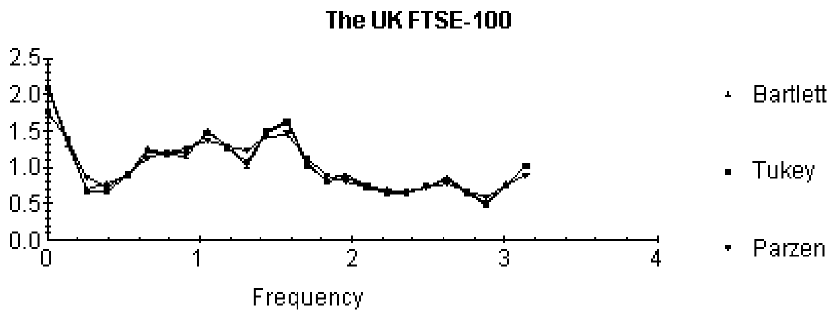


Figure 11

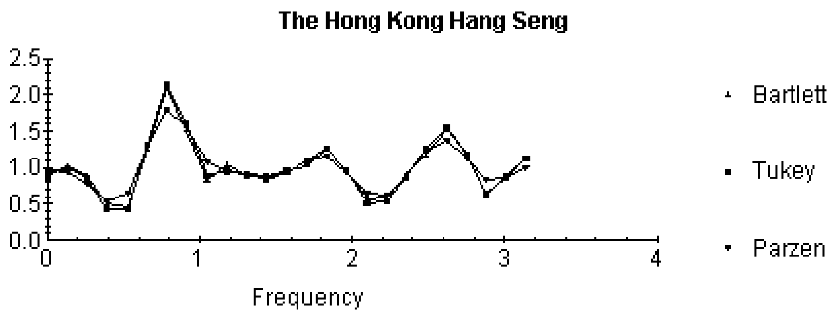
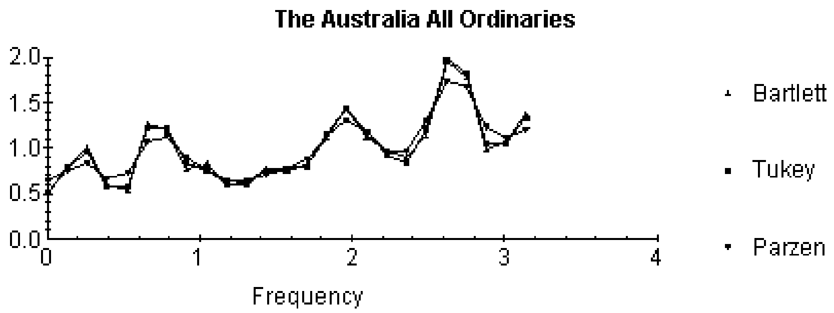


Figure 12



5 Conclusion

This paper has re-tested the random walk hypothesis for the stock markets of the US, Japan, the UK, Germany, Hong Kong and Australia. The results show that contrary to recent findings that the stock prices of these countries follow a random walk. While the Johansen-Juselius tests suggest that all markets are cointegrated and share a long run trend, the vector error correction models imply that the US, Germany and Australia can also stand to gain in the short term through stock market trading.

References:

Alexander, S. (1961), "Price Movements in Speculative Markets: Trends or Random Walks?" in Cootner (1964) ed., *The Random Character of Stock Market Prices*, MIT Press, MA.

Cootner, P.H. (1964), "The Random Character of Stock Market Prices," MIT Press, MA.

Davidson, R. and MacKinnon, J.G. (1993), *Estimation and Inference in Econometrics*, Oxford University Press, Oxford.

Dickey, D.A. and Fuller, W.A. (1979), "Autoregressive Time Series With a Unit Root", *Journal of the American Statistical Association,* 74, 427-431.

Enders, W. (2004), *Applied Econometric Time Series*, John Wiley & Sons Inc., New York.

Engle, R.F. and Granger, C.W.C. (1987), "Co-integration and Error Correction: Representation, Estimation and Testing", *Econometrica,* 55(2), 251-276.

Fama, E. (1965), "The Behaviour of Stock Market Prices", *Journal of Business,* 38, 34-105.

Gallagher, L. and Taylor, M. (2002), "Permanent and Temporary Components of Stock Prices: Evidence from Assessing Macroeconomic Stocks", *Southern Economic Journal,* 69, 345-362.

Jarque, C.M. and Bera, A.K. (1980), 'Efficient Tests for Normality, Homoscedasticity and Serial Independence of Regression Residuals", *Economics Letters,* 6, 255-59.

Johansen, S. (1988), "Statistical Analysis of Cointegration Vectors", *Journal of Economic Dynamics and Control,* 12, 231-254.

Johansen, S. and Juselius, K. (1990), "Maximum Likelihood Estimation and Inference on Cointegration – with Applications to the Demand for Money", *Oxford Bulletin of Economics and Statistics,* 52, 169-210.

Kendall, M.G. (1953), "The Analysis of Economic Time Series, Part 1: Prices," in Cootner (1964), ed., *The Random Character of Stock Market Prices*, MIT Press, MA.

Lo, A.W, MacKinlay, A.C. (1997), "Stock Market Prices Do Not Follow Random Walks", *Market Efficiency: Stock Market Behaviour in Theory and Practice,* 1, 363-389.

Phillips, P. (1987), "Time Series Regression with a Unit Root", *Econometrica,* 55, 277-301.

Phillips, P. and Perron, P. (1988), "Testing for a Unit Root in Time Series Regression", *Biometrica,* 75, 335-46.

Ramsey. J.B. (1969), "Test for Specification Errors in Classical Linear Least Squares Regression Analysis", *Journal of Royal Statistical Society,* B, 350-371.

Roberts, H.V. (1959), "Stock Market 'Patterns' and Financial Analysis: Methodological Suggestions", in Cootner (1964) ed., *The Random Character of Stock Market Prices*, MIT Press, MA.

Taylor, S. (2000), "Stock Index Price Dynamics in the UK and the US: New Evidence from a Trading Rule and Statistical Analysis", *European Journal of Finance,* 6, 39-69.

Economics Discussion Papers

2003-01 On a New Test of the Collective Household Model: Evidence from Australia, **Pushkar Maitra** and **Ranjan Ray**

2003-02 Parity Conditions and the Efficiency of the Australian 90 and 180 Day Forward Markets, **Bruce Felmingham** and **SuSan Leong**

2003-03 The Demographic Gift in Australia, **Natalie Jackson** and **Bruce Felmingham**

2003-04 Does Child Labour Affect School Attendance and School Performance? Multi Country Evidence on SIMPOC Data, **Ranjan Ray** and **Geoffrey Lancaster**

2003-05 The Random Walk Behaviour of Stock Prices: A Comparative Study, **Arusha Cooray**

2003-06 Population Change and Australian Living Standards, **Bruce Felmingham** and **Natalie Jackson**

2003-07 Quality, Market Structure and Externalities, **Hugh Sibly**

2003-08 Quality, Monopoly and Efficiency: Some Refinements, **Hugh Sibly**

2002-01 The Impact of Price Movements on Real Welfare through the PS-QAIDS Cost of Living Index for Australia and Canada, **Paul Blacklow**

2002-02 The Simple Macroeconomics of a Monopolised Labour Market, **William Coleman**

2002-03 How Have the Disadvantaged Fared in India? An Analysis of Poverty and Inequality in the 1990s, **J V Meenakshi** and **Ranjan Ray**

2002-04 Globalisation: A Theory of the Controversy, **William Coleman**

2002-05 Intertemporal Equivalence Scales: Measuring the Life-Cycle Costs of Children, **Paul Blacklow**

2002-06 Innovation and Investment in Capitalist Economies 1870:2000: Kaleckian Dynamics and Evolutionary Life Cycles, **Jerry Courvisanos**

2002-07 An Analysis of Input-Output Interindustry Linkages in the PRC Economy, **Qing Zhang** and **Bruce Felmingham**

2002-08 The Technical Efficiency of Australian Irrigation Schemes, **Liu Gang** and **Bruce Felmingham**

2002-09 Loss Aversion, Price and Quality, **Hugh Sibly**

2002-10 Expenditure and Income Inequality in Australia 1975-76 to 1998-99, **Paul Blacklow**

2002-11 Intra Household Resource Allocation, Consumer Preferences and Commodity Tax Reforms: The Australian Evidence, **Paul Blacklow** and **Ranjan Ray**

Copies of the above mentioned papers and a list of previous years' papers are available on request from the Discussion Paper Coordinator, School of Economics, University of Tasmania, Private Bag 85, Hobart, Tasmania 7001, Australia. Alternatively they can be downloaded from our home site at http://www.utas.edu.au/economics