On Tests for Long Memory in Pacific Basin Stock Returns

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Abstract There have been growing interest in studying the behaviour of stock returns over long versus short horizons. Previous studies showed that while autocorrelations in returns usually are positive or close to zero over short horizons, they become negative over long horizons. In this article we examine the behaviour of stock returns in four Pacific Basin stock markets based on long-memory analysis. Three tests which are robust to short-term dependence and conditional heteroskedasticity are employed. They are the modified rescaled range test, the fractional differencing test based on raw periodograms and the fractional differencing test with the Bartlett window-smoothed periodograms. The empirical findings in general provide little support for long memory in Pacific Basin stock returns.

1 INTRODUCTION

The previous studies by Stambaugh (1986), Fama and French (1988), and Poterba and Summers (1988) concluded that stock returns in U.S. market exhibit positive autocorrelations over short horizons and negative autocorrelations over long horizons. The reported anomalous behaviour of stock returns can be a symptom of long memory processes discussed in Granger and Joyeux (1980). Lo (1991) employed a modified rescaled range (R/S) test to detect long memory in U.S. stock returns. In this paper we search for long memory in four Pacific Basin stock market daily returns. In addition to the Lo's (1991) modified R/S test, we also consider the GPH test and the modified GPH test which are proposed by Geweke and Porter-Hudak (1983) and Chen, Abraham and Peiris (1994), respectively.

The plan of this paper is as follows. Section 2 gives a brief review on the three tests of long memory. In Section 3 we describe the data and present the test results. Finally some concluding remarks are given in Section 4.

2 TESTS FOR LONG MEMORY

2.1 The Modified R/S Test

The modified R/S test is an improved version of the classical R/S test which was proposed by Hurst (1951) while studying hydrological time series of the River Nile.

For a return series $\{ x_1, x_2, \ldots, x_T \}$, Lo (1991) refined the classical test by defining

$$Q_T = \hat{R}/\hat{\sigma}_T(q) \quad (1)$$

where

$$\hat{R} = \max_{0<i\le T} \sum_{t=1}^{i} (x_t - \overline{x}) - \min_{0<i\le T} \sum_{t=1}^{i} (x_t - \overline{x}),$$

$$\hat{\sigma}_T^2(q) = \hat{\sigma}^2 + 2\sum_{j=1}^{q} w_j(q)\hat{\gamma}_j,$$

$$w_j(q) = 1 - |j/q|,$$

with $\hat{\sigma}^2$, $\overline{x}$ and $\hat{\gamma}_j$ being the usual sample variance, mean and lag-j autocovariance for the data. The truncation lag q is determined by

$$q = \mathtt{int}\left[\left(\frac{3T}{2}\right)^{1/3}\left(\frac{2\hat{\rho}}{1-\hat{\rho}^2}\right)^{2/3}\right]$$

where $\hat{\rho}$ is the first-order sample autocorrelation coefficient and $\mathtt{int}[\cdot]$ is the integer function.

Under the null hypothesis of no long memory, Lo (1991) showed that the limiting distribution of the Q_T statistic in (1) is given by the distribution function of the difference between the maximum and minimum of the Brownian bridge on a unit interval. Therefore, we can easily obtain the p-value of the test.

2.2 The GPH Test

Granger and Joyeux (1980) generalized the orthodox $ARIMA(p, d, q)$ models by allowing the degree of integration d to be non-integers. This new class of fractionally differenced processes can be used to model parametrically long-memory dynamics. Hosking (1981) showed that the fractional parameter d crucially determines the low-frequency spectrum of the underlying process. When $d = 0$, the stationary time series $\{x_1, x_2, \ldots, x_T\}$ will display long memory and the parameter d is amendable to estimation and hypothesis testing.

Geweke and Porter-Hudak (1983) proposed to use the periodogram to estimate the spectral density at low harmonic frequencies. A least square regression on the logarithms of the spectral density against a sequence of constants can be used to estimate d by the slope. The spectral regression is given as

$$\ln[\hat{I}(w_j)] = \eta + d\ln[2\sin(w_j/2)]^2 + e_j$$

where

$$\hat{I}(w_j) = \frac{1}{2\pi}\Big[\sum_{i=-(T-1)}^{T-1} \hat{\gamma}_i \cos(iw_j)\Big]$$

is the periodogram at harmonic frequency $w_j = 2\pi j/T$, $\hat{\gamma}_i$ is the usual lag-i sample autocovariance, and $j = 1, 2, \ldots, n$ with $n = \sqrt{T}$. Under the null hypothesis of no memory, the slope of the regression d equals zero. The usual t-statistic can be employed to perform the test.

2.3 The Modified GPH Test

The GPH test employs a periodogram which is an unbiased but inconsistent estimator to estimate the spectral density. Chen, Abraham and Peiris (1994) modified the GPH test by smoothing the periodogram using the Bartlett's (1950) window. The smoothed periodogram is given by

$$\hat{I}(w_j) = \frac{1}{2\pi}\Big[\sum_{i=-(T-1)}^{T-1} B(i)\hat{\gamma}_i \cos(iw_j)\Big]$$

where $B(u) = 1 - |u|/M$ is the Bartlett's window with the window parameter chosen to be $M = T/2$. Denoting $\hat{d}_B$ as the estimator of d obtained by the spectral regression method using smoothed periodogram, Chen *et al* (1994) further proposed the following normal approximation to the distribution of $\hat{d}_B$ for finite sample size T,

$$\hat{d}_B \sim N(d, \sigma_B^2),$$

where

$$\sigma_B^2 = \frac{\Psi'(2\alpha)}{\sum_{j=1}^{\sqrt{T}}(\mu_j - \overline{\mu})^2},$$

$$\alpha = \int_{-1}^{1} B(z)dz,$$

$$\Psi'(z) = \frac{d^2}{dz^2}\ln[\Gamma(z)]$$

with $\mu_j = \ln[2\sin(w_j/2)]^2, \overline{\mu}$ is the mean of μ_j and $\Gamma(z)$ is the Gamma function.

3 DATA AND TEST RESULTS

Four Pacific Basin stock markets, namely, Australia, Hong Kong, Singapore and Japan are examined in this study. These markets are selected based on three practical concerns. They are: (1) availability of reliable stock data, (2) maturity of the market and (3) accessibility to foreign investors. Thus, Korea and Taiwan markets have been excluded. The markets included in this study accounted for more than 95% of the entire region.

The following daily market indices are used to represent the selected countries:
[1] The Australia All Ordinary Share Index: This is a market-value weighted index covering about 90% of the total market capitalisation.
[2] The Hong Kong Hang Seng Index: This index is composed of 33 constituent stocks selected from all sectors. It is a market-value weighted and represents about 70% of total market capitalisation.
[3] The Stock Exchange of Singapore All-Share Index: The SES index is a market-value weighted index of all stocks traded on the exchange.
[4] The Tokyo Stock Price Index: This index covers over 1100 stocks in the First Section of the Tokyo Stock Exchange and is market-value weighted.

Our study covers the period from January 1975 through December 1994 except for the Australian market. The Australian All Ordinary Share Index is available only after January 1981. As each market will be analysed separately, different sample periods should not pose any problem to our study. Figure 1 presents the daily movements of the market indices for different countries. It is obvious that all markets were affected by the crash in October 1987, with the effect on Japanese market being the smallest. Apart from the crash, the Singapore market suffered heavy losses in December 1985 due to the Pan-Electric crisis, and the Hong Kong market was affected by the Tiananmen Square incident in June 1989. The Gulf war in August 1990 also caused much havoc, with Singapore being the most seriously affected.

Table 1 provides several descriptive statistics, including mean ($\overline{x}$), standard deviation ($\hat{\sigma}$), skewness (τ_3), excess kurtosis (τ_4) and the first order autocorrelation coefficient ($\hat{\rho}_1$). The significance (at the 5% level) of $\hat{\rho}_1$ in all countries suggests the presence of short-term dependence of the return series. The AR(1)-ARCH(1) model, introduced by Engle (1982), is also fitted to the return series. Conditional heteroskedasticity is found in the Australia and Hong Kong markets. Our preliminary data analysis results indicate the presence of short-term dependence and apparent conditional heteroskedasticity. However, in a simulation study, Cheung (1993) reported that the modified R/S and the GPH tests are robust to short-term dependence and conditional heteroskedastic effects. Therefore, the tests which we have described in Sec-

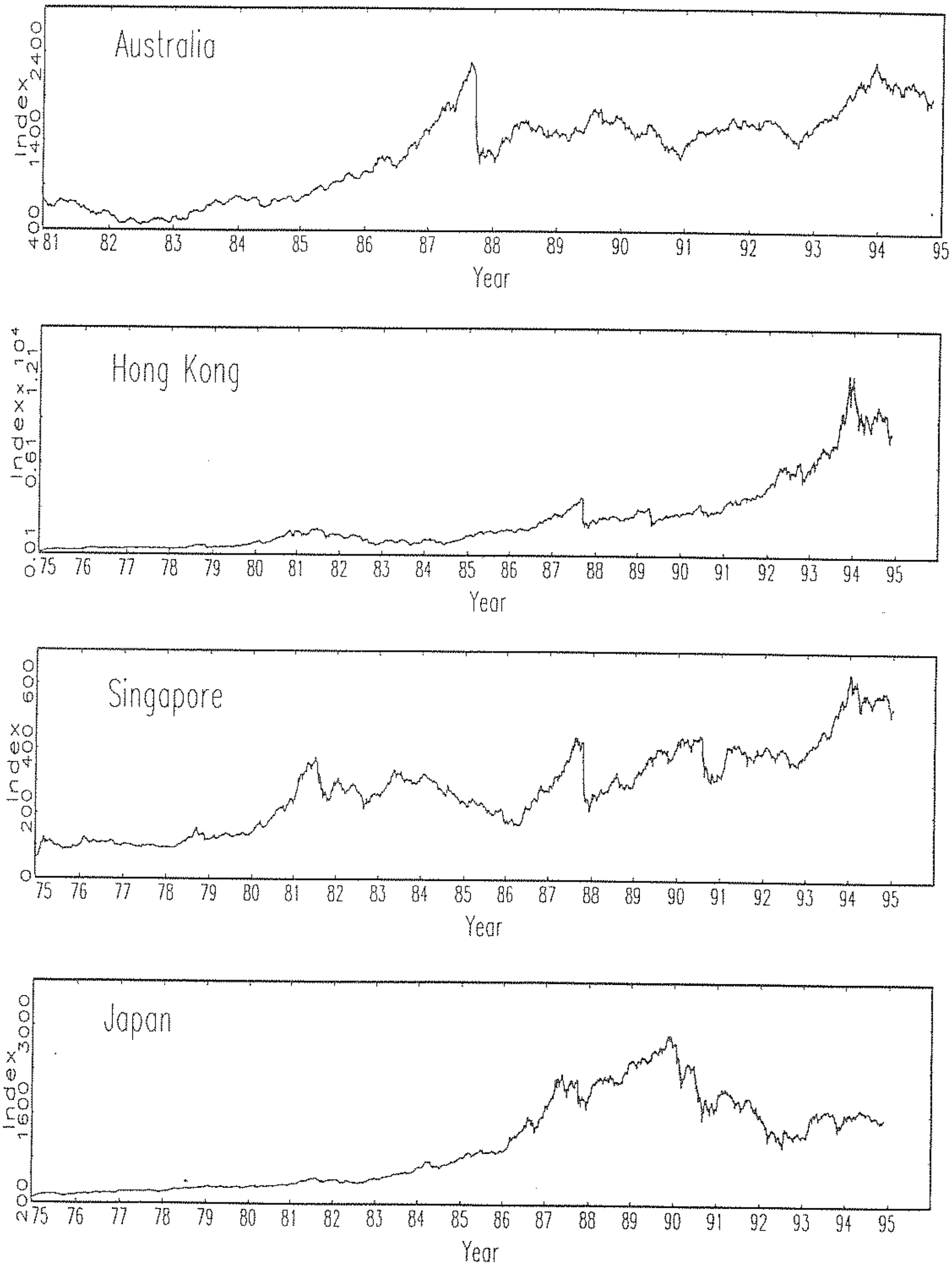

Figure 1: Prices Indices of Four Pacific Basin Stock Markets

Table 1: Descriptive Statistics for the Return Series

Country	T	$\overline{x}(\times 10^{-4})$	$\hat{\sigma}$	τ_3	τ_4	$\hat{\rho}_1$
Australia	3522	2.78	0.0107	-5.99	155.7	0.1196
Hong Kong	4932	7.89	0.0180	-3.12	65.8	0.0660
Singapore	5003	4.34	0.0122	-1.96	52.6	0.1470
Japan	4930	3.54	0.0096	-0.68	30.9	0.1091

tion 2 are still useful for detecting long memory in our selected return series.

The test results are summarised in Table 2. For each test, the test statistic and its corresponding p-value (in parenthesis) are given. For the modified R/S test, there is only one (Australia) case can the null hypothesis of no long memory be rejected at the 5% level. The results for the GPH and the modified GPH tests uniformly show that there is no case can the null hypothesis of no long memory be rejected at the 5% or even the 10% level. The findings in this study are consistent with the results by Lo (1991) for U.S. market and Cheung, Lai, and Lai (1993) for four major foreign markets. Thus, the empirical findings from different studies so far provide little support for long memory in international stock returns.

4 CONCLUDING REMARKS

We have examined long memory behaviour of stock returns in four Pacific Basin stock markets. Our study includes the modified rescaled range test, the fractional differencing tests based on raw periodograms and on the Bartlett window. The empirical results, consistent with other studies, are not supportive of the presence of long memory in the Pacific Basin stock markets.

Table 2: Results of Various Tests for Long Memory

Country	Modified R/S	GPH	Modified GPH
Australia	1.7526	-0.0133	-0.0632
	(0.0485)	(0.5566)	(0.9160)
Hong Kong	1.1063	-0.0579	0.0171
	(0.6759)	(0.7523)	(0.3405)
Singapore	1.2661	0.0087	0.0289
	(0.4387)	(0.4593)	(0.2432)
Japan	1.6778	0.0351	0.03827
	(0.0737)	(0.3395)	(0.1787)

Notes: Figures in parentheses are the p-values.

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