DO STOCK PRICES FOLLOW RANDOM WALK ? :

SOME INTERNATIONAL EVIDENCE

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ABSTRACT

Although empirical studies in the past found the random walk hypothesis for the U.S. stock returns difficult to reject, recent studies report that U.S. stock returns can be predicted from past returns. In this study, the issue of whether the aggregate weekly stock returns of 10 other industrialized countries—namely, Australia, Belgium, Canada, France, Italy, Japan, Netherlands, Switzerland, United Kingdom, and West Germany—follow the random walk process is investigated for the 1967–1988 period. A variance ratio test that is heteroscedasticity-robust is employed. It is found that the random walk model is still the appropriate characterization of the weekly return series for the majority of these countries.

1. INTRODUCTION

Empirical studies until recently have provided overwhelming support for the notion that the U.S. stock prices cannot be predicted from the historical prices [e.g., Roll (1970), Samuelson (1973), and Fama and MacBeth (1973)]. Stock prices cannot be predicted

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from the past prices if they do not exhibit statistically significant (either positive or negative) autocorrelation over time.

During the past few years, however, a series of studies have challenged the validity of these results. They, unlike the previous studies, find that the stock returns are related to the past returns.

Fama and French (1988) show that three- to five-year holding period returns are negatively autocorrelated, i.e., stock prices exhibit mean reversion.[1] Poterba and Summers (1988) find that the stock returns are positively autocorrelated at horizons shorter than one year and negatively autocorrelated at longer horizons. Lo and MacKinlay (1988) present evidence that weekly portfolio stock returns are positively autocorrelated. French and Roll (1986) and Lo and MacKinlay (1988) document that daily and weekly individual security returns are negatively correlated.

There are two competing explanations of this phenomenon. First, the serial correlation of stock returns may reflect the overreaction of stock prices to information. Second, the serial correlation of returns can be induced by time-varying expected returns in an efficient market.

"Overreaction hypothesis" is supported by recent empirical studies that document the profitability of contrarian investment strategies [e.g., DeBondt and Thaler (1985, 1987, 1990), Lehman (1990)].[2] A contrarian investment strategy consists of buying stocks that have been prior "losers" and selling short stocks that have been prior "winners". Many investors engage in these unconventional strategies in an attempt to exploit the possibility that the stock market overreacts to the news, hoping that stocks of the firms experiencing a series of good earnings, for example, are overvalued and stocks of those firms with poor earnings record are undervalued.[3] Obviously, contrarian strategies would be profitable if the stock returns are negatively correlated.

Time-varying behavior of expected returns is also supported by several recent studies. Conrad and Kaul (1988) find that the expected returns are positively autocorrelated. Dividend yield and default spread [e.g., Fama and French (1989) and Chen, Roll and Ross (1986)] and term spread [e.g., Keim and Stambaugh (1986)] are found to vary negatively with the expected returns. Fama and French (1989) find that the variations in expected returns are negatively related to the variations in business conditions. Fama (1990) attributes the negative correlation between expected returns and business conditions to the existence of positive relationships between business conditions and dividend yield, default spread and term spread.

Also a positive relationship between expected returns and time-varying volatility is found to exist [e.g., Akgiray (1989), Pindyck (1984), French, Schwert and Stambaugh (1987) and Ball and Kothari (1989)].

As such, the argument that the U.S. stock returns are intertemporally related has been steadily gaining momentum during the past several years.

However there has been a paucity of studies during the recent years addressing the issue of whether the stock returns of other industrialized nations are also related over time[4]. Only Poterba and Summers (1988) provide evidence for the foreign stock markets.

Using the monthly data of 17 countries for the period January,1957 to December,1986, they conclude that the null hypothesis of serial independence of stock returns cannot be rejected for any individual country. However, they also state that their results may be biased due to the small data samples used and associated large standard error of the estimates.

The purpose of this study is to fill a void in the existing literature by testing whether aggregate stock returns are related over time for ten other industrialized nations—namely, Australia, Belgium, Canada, France, Italy, Japan, Netherlands, Switzerland, United Kingdom, and West Germany.[5] The data employed is the weekly stock returns from December 29, 1967 to October 21, 1988.

The empirical procedure employed in this study is the specification test based on the variance ratios recently developed by Lo and MacKinlay (1988).

The variance ratio test focuses on the dynamic behavior of the random component of the stock returns. According to the variance ratio test, the variance of the k-period holding return should be approximately k times the variance of the one-period return if the stock returns are serially independent (i.e., they follow the random walk).

In light of recent evidence that the volatility of stock returns varies over time in both the U.S. and foreign equity markets [e.g., Akgiray (1989), Schwert and Seguin (1990) and Hamao, Masulis and Ng (1990)], Lo and MacKinlay's procedure does a good job in detecting the correlation of stock returns without being affected by the presence of time-varying volatility of stock returns.[6] Also, Monte Carlo experiments performed by Lo and MacKinlay (1989) show that the variance ratio test is more reliable than alternative statistical procedures (e.g., Box-Pierce Q test) for detecting serial correlations of stock returns.

There are three distinct advantages in using the weekly data in this study. First, weekly sampling makes it easier to employ a large number of observations while minimizing the biases associated with the infrequent trading and bid-ask spread that are very common with the daily data [see Lehman (1990)].

Lo and Mackinlay (1988) suggest that since the variance ratio tests are based on asymptotic approximations, a large number of data is needed for estimation in order to generate meaningful results.[7] Also employing a large number of weekly data would circumvent the biases that Poterba and Summers (1988) might have experienced.

Second, the time series property of weekly returns can be significantly different from that of monthly returns [see Lo and MacKinlay (1988)]. Therefore, the findings of this study can shed useful insight into the dynamic behavior of foreign equity markets beyond those generated by Poterba and Summers (1988).

Third, using the weekly stock returns in this study would enable one to directly compare results with those of Lo and MacKinlay (1988). Lo and MacKinlay employ the weekly U.S. data for the period from September 6, 1962 to December 26, 1985, roughly coinciding with that of this study.

The empirical results for the sample period as well as for two subperiods indicate that the random walk model is still the appropriate characterization of the stock returns for most of the countries. Furthermore, when the test is performed using the base observation period of four weeks, the random walk hypothesis cannot be rejected for all ten countries. Thus the findings of this study are inconsistent with those of Lo and MacKinlay (1988) who find the weekly U.S. stock returns do not follow the random walk.

The plan of this study is as follows. Section 2 presents a brief description of the variance ratio test used in this study. Section 3 describes the data employed in the study and explains the empirical results. Section 4 summarizes the findings.

2. VARIANCE RATIO TEST PROCEDURE

Let's suppose the stochastic behavior of stock prices is assumed to follow a Gaussian random walk with a drift of the following form:

$$\log(P_t/P_{t-1}) = \mu + \xi_t, \tag{1}$$

where P_t is the stock price at time t, μ is a drift in the underlying stochastic process and ξ_t is the random component with zero mean and finite variance. $\text{Log}(P_t/P_{t-1})$ is equivalent to one-period return from $t-1$ to t.

If stock prices follow the random walk with a drift, then ξ_t in (1) should be serially independent. Therefore, it is necessary to isolate the random component from the rest of the return series before a detailed study of the dynamic behavior of the random component can be performed.

This can be accomplished by taking overlapping finite differences of the log-price series [see Lo and MacKinlay (1988) and Ma (1990)]. The finite differencing method simply involves computing the price changes or return over certain length of time periods. So the qth differencing of (1) results in the q-period return, $\log(P_t/P_{t-q})$. The finite differencing will not alter the dynamic pattern of the random component [see Powers (1971)]. Also overlapping differencing will result in significantly larger sample sizes.

The series should be differenced q times, where q is the number of differencing required to eliminate the probable effect of the systematic component.

The gist of the variance ratio test can be explained as follows. Assuming the log-price series is differenced q times, so that the systematic component is eliminated, the variance of q-week return should be q times as large as the variance of a weekly sample if ξ_t follows the random walk with a drift. Therefore, if the ratio of $1/q$th of the variance of q-week return over the variance of the one-week return is statistically different from 1 the random walk hypothesis can be rejected.

Since time-varying behavior of the stock return volatilities is empirically well documented, rejection of the random walk hypothesis because of the presence of heteroscedasticity in stock returns would not provide useful insight into the stochastic behavior of stock prices. Lo and MacKinlay's procedure circumvents this problem.

Invoking Hausman's (1978) result that the asymptotic variance of the difference between two variables is simply the difference of the asymptotic variances of these two variables, Lo and Mackinlay (1988) show that the value of the variance ratio minus one is asymptotically normally distributed under the null hypothesis of random walk process.[8]

If the null hypothesis of random walk behavior is true, then the standardized test statistic $z^*(q) = T\,M_r(q)/\sqrt{\Theta}(q)$ is distributed as asymptotically normal even in the presence of general heteroscedasticity, where $M_r(q)$ is the ratio of q-week return variance over one-week return variance minus one,

$$\Theta(q) = \sum_{j=1}^{q-1} \left[\frac{2(q-j)}{q}\right]^2 d(j), \tag{2}$$

$$d(j) = \frac{\sum_{t=j+1}^{T} (X_t - X_{t-1} - \mu)^2 (X_{t-j} - X_{t-j-1} - \mu)^2}{\left[\sum_{t=1}^{T} (X_t - X_{t-1} - \mu)^2\right]^2}, \tag{3}$$

and T is the number of observations. X_t denotes the log of the stock prices. That is, $X_t = \log(P_t)$.

Both the variance ratios and the corresponding $z^*(q)$ statistic as described above are employed in Section 3 to test empirically the random walk test for the weekly stock return data of ten industrialized countries. The estimates of the variance ratios of different lags and their associated test statistics can be used to assess if the variance ratios are significantly different from unity.

3. DATA AND EMPIRICAL RESULTS

Since the data on stock returns that are needed for this study are weekly data, the Barron's National Business and Financial Weekly was chosen as the source of data. Barron's regularly publishes Friday closing prices of the aggregate stock indexes of major industrialized nations besides the United States. These indexes are broadly based and market value weighted. These indexes are also based on local currencies and do not include dividends. Table 1 presents a list of the stock indexes for the ten industrialized nations employed in this study.

A large number of observations is needed for this study since the variance ratio test procedure is based wholly on asymptotic approximations. As such, the time period that is examined here is relatively long, covering the period December 29, 1967 to October 21, 1988 (1091 observations).

The weekly return of each country corresponding to a given week is computed as the return from the previous Friday's closing price to the current Friday's closing price.

Table 1. Stock Indexes of Ten Industrialized Nations

Locality	*Exchange*	*Index*
Australia	Sydney	All Ordinaries
Belgium	Brussels	Stock Index
Canada	Toronto	TSE 300
France	Paris	Agefi
Italy	Milan	M.I.N.
Japan	Tokyo	Tokyo Stock Exchange
Netherlands	Amsterdam	ANP-CBS General
Switzerland	Zurich	Swiss Bank Corp.
United Kingdom	London	Financial Times
West Germany	Frankfurt	Commerzbank

Stock indexes of some of the ten countries have been rebased few times. Belgium's aggregate stock index has been rebalanced four times and Switzerland's stock index two times during the sample period. The aggregate stock index of Italy, France, and Netherlands each has been rebalanced one time.

Section (i) presents empirical results for a one-week base observation period for the whole sample period as well as for two subperiods, using aggregation values q ranging from 2 to 16. The first subperiod covers from December 29, 1967 to May 19, 1978, and the second subperiod from May 26, 1978 to October 21, 1988. Section (ii) presents corresponding test results for a four-week base observation period.

i. Results for a One-week Base Observation Period

Table 2 reports the variance ratio, $1 + M_r(q)$, and the test statistic, $z^*(q)$, corresponding to each of the ten countries for a one-week base observation period. The values reported in the main rows are the actual variance ratios and the entries enclosed in parentheses are the $z^*(q)$ statistics. Four different values of q—2, 4, 8 and 16—are used.

It should be noted that the value of q should be significantly large so as to eliminate the impact of the systematic component in the original log-price series. Therefore, the results obtained for $q = 8$ and $q = 16$ should reflect more accurately the dynamic properties of the random component than those obtained with smaller values of q.

Random walk null hypothesis is rejected for both Australia and Belgium at the 5% significance level for 4 different values of q. For Italy, the null hypothesis is rejected only for $q = 2$. In the case of Netherlands, the null hypothesis is rejected for both $q = 2$ and $q = 4$. For other six countries (i.e., Canada, France, Japan, Switzerland, United Kingdom and West Germany), the null hypothesis cannot be rejected at the 5% significance level for all 4 values of q.

Since the results for $q = 8$ and $q = 16$ are more reliable than those for smaller values of q, it can be safely stated that the random walk hypothesis is rejected only for Australia

Table 2. Foreign Stock Market Index Results for a One-week Base Observation Period: Decembor 29, 1967 – October 21, 1988

	Number of base observations aggregated to form variance ratio (q)			
Country	*2*	*4*	*8*	*16*
Australia	1.1880	1.3983	1.5998	1.6403
	(6.2108)*	(7.0321)*	(6.6977)*	(4.8045)*
Belgium	1.1502	1.3906	1.5843	1.5373
	(4.9606)*	(6.8959)*	(6.5242)*	(4.0320)*
Canada	.9111	.8857	.9207	.8772
	(–2.9375)	(–2.0174)	(–.8860)	(–.9218)
France	.9801	.9599	.9891	.9917
	(–.6566)	(–.7080)	(–.1219)	(–.0624)
Italy	.9055	.8888	.8541	.7314
	(–3.1199)*	(–1.9631)	(–1.6293)	(–2.0154)
Japan	.9999	1.0237	1.0880	1.1588
	(–.0001)	(.4185)	(.9826)	(1.1914)
Netherlands	.8136	.7987	.8177	.8824
	(–6.1560)*	(–3.5543)*	(–2.0358)	(–.8822)
Switzerland	.9742	.9657	1.0038	.9669
	(–.8531)	(–.6049)	(.0428)	(–.2481)
United Kingdom	.9316	.9574	1.0034	.9797
	(–2.2585)	(–.7527)	(.0382)	(–.1525)
West Germany	1.0577	1.2276	1.3050	1.3394
	(1.9056)	(4.0192)	(3.4053)	(2.5467)

Note: The variance ratios, $1 + M_r(q)$, are reported in the main rows with the heteroscedasticity-robust test statistics, $z^*(q)$, given in parentheses. Under the random walk null hypothesis, the value of the variance ratio is 1 and the test statistic has a standard normal distribution. Test statistic with the asterisk indicates that the corresponding variance ratios are statistically different from 1 at the 5 percent significance level.

and Belgium. The stock returns of the other eight countries can be modeled as the random walk process.

These results are different from those of Lo and MacKinlay (1988) who reject the random walk hypothesis for the weekly U.S. stock returns.[9] Also the results are somewhat inconsistent with those of Poterba and Summers (1988) who cannot reject the random walk hypothesis for the monthly returns of Belgium.

The results obtained should not be affected by changing variances of stock returns over time since the $z*(q)$ statistics are robust to the heteroscedastic properties of return variances. Also the results are not subject to the small-sample biases.

Table 3. Foreign Stock Market Index Results for a One-week Base Observation Period: December 29, 1967 – May 19, 1978

	Number of base observations aggregated to form variance ratio (q)			
Country	*2*	*4*	*8*	*16*
Australia	1.0811	1.2263	1.3914	1.6484
	(1.8926)	(2.8239)	(3.0891)	(3.4386)
Belgium	1.1764	1.3876	1.4294	1.5762
	(4.1169)*	(4.8361)*	(3.3889)*	(3.0557)*
Canada	1.0688	1.2639	1.3803	1.2461
	(1.6062)	(3.2933)*	(3.0017)*	(1.3055)
France	1.0237	1.0923	1.1913	1.2606
	(.5520)	(1.1522)	(1.5094)	(1.3820)
Italy	1.0263	1.1733	1.1841	.9977
	(.6145)*	(2.1630)*	(1.4533)*	(–.0121)
Japan	1.0159	1.0491	1.1550	1.2769
	(.3710)	(.6124)	(1.2233)	(1.4687)
Netherlands	.7823	.7819	.7637	.8401
	(–5.0815)*	(–2.7213)*	(–1.8651)	(–.8479)
Switzerland	.9833	1.0697	1.1174	1.1228
	(–.3896)	(.8692)	(.9267)	(.6513)
United Kingdom	1.0144	1.1326	1.2918	1.3745
	(.3367)	(1.6542)	(2.3032)*	(1.9860)*
West Germany	.9642	1.0058	1.0206	1.0270
	(–.8369)	(.0727)	(.1627)	(.1434)

Note: The variance ratios, $1 + M_r(q)$, are reported in the main rows with the heteroscedasticity-robust test statistics, $z^*(q)$, given in parentheses. Under the random walk null hypothesis, the value of the variance ratio is 1 and the test statistic has a standard normal distribution. Test statistic with the asterisk indicates that the corresponding variance ratios are statistically different from 1 at the 5 percent significance level.

The variance ratio, $M_r(q) + 1$, in Table 2 that corresponds to $q = 2$ can be approximated as one plus the first-order autocorrelation coefficient of the weekly returns. Therefore, from Table 2, the first-order autocorrelation coefficient for Australia can be computed as .1880 and that for Canada as –.0889, and so on. It is found that only the weekly stock returns for Australia, Belgium and West Germany exhibit positive first-order autocorrelation. For the other seven countries, the weekly returns exhibit negative first-order autocorrelation (i.e., mean reversion process). These findings contrast sharply with the Lo and MacKinlay's (1988) result that the first-order autocorrelation coefficient for the U.S. weekly stock returns is positive.

Table 4. Foreign Stock Market Index Results for a One-week Base Observation Period: May 26, 1978 – October 21, 1988

	Number of base observations aggregated to form variance ratio (q)			
Country	*2*	*4*	*8*	*16*
Australia	1.2649	1.5261	1.7657	1.6652
	(6.1836)*	(6.5651)*	(6.0434)*	(3.5280)*
Belgium	1.1285	1.3663	1.5965	1.3461
	(2.9989)*	(4.5711)*	(4.7075)*	(1.8358)*
Canada	.8595	.7633	.7753	.7602
	(–3.2799)*	(–2.9543)*	(–1.7737)	(–1.8358)
France	.9360	.8262	.7908	.7231
	(–1.4947)	(–2.1683)	(–1.6510)	(–1.4688)
Italy	.8811	.8316	.7897	.6749
	(–2.7756)*	(–2.1012)	(–1.6596)	(–1.7241)
Japan	.9777	.9954	1.0091	1.0380
	(–.5198)	(–.0576)	(–.0715)	(.2015)
Netherlands	.8411	.8118	.8617	.9094
	(–3.7095)	(–2.3481)	(–1.0914)	(–.4807)
Switzerland	.9704	.8882	.9298	.8778
	(–.6914)	(–1.3952)	(–.5538)	(–.6481)
United Kingdom	.8438	.7735	.7067	.5855
	(–3.6464)*	(–2.8266)*	(–2.3144)	(–2.1982)
West Germany	1.1445	1.4352	1.5838	1.6768
	(3.3736)*	(5.4304)*	(4.6074)*	(3.5895)*

Note: The variance ratios, $1 + M_r(q)$, are reported in the main rows with the heteroscedasticity-robust test statistics, $z^*(q)$, given in parentheses. Under the random walk null hypothesis, the value of the variance ratio is 1 and the test statistic has a standard normal distribution. Test statistic with the asterisk indicates that the corresponding variance ratios are statistically different from 1 at the 5 percent significance level.

The variance ratios of those countries with the positive first-order autocorrelation of returns—Australia, Belgium and West Germany—increase with q. However, the magnitude of the corresponding $z^*(q)$ statistics is found not to increase in tandem. These results are consistent with those of Lo and MacKinlay (1988). On the other hand, the variance ratios of seven other countries with negative first-order autocorrelation coefficient do not exhibit consistent patterns with incremental changes in q.

Tables 3 and 4 present the variance ratios and the corresponding $z^*(q)$ statistics for two subperiods of equal time length, December 29, 1967–May 19, 1978 and May 26, 1978–October 21, 1988, respectively. For the first subperiod, the returns for Belgium

Table 5. Foreign Stock Market Index Results for a Four-week Base Observation Period: December 29, 1967 – October 21, 1988

	Number of base observations aggregated to form variance ratio (q)			
Country	*2*	*4*	*8*	*16*
Australia	1.1113	1.1462	1.0510	1.1124
	(1.8347)	(1.2892)	(.2843)	(.4211)
Belgium	1.1677	1.1494	1.0629	1.2089
	(2.7665)*	(1.3169)	(.3507)	(.7827)
Canada	1.1286	1.1704	1.2414	1.1967
	(2.1213)	(1.5018)	(1.3458)	(.7372)
France	.9580	.9706	.9286	.7599
	(–.6930)	(–.2593)	(–.3979)	(–.8996)
Italy	.8858	.7380	.6484	.6372
	(–1.8834)	(–2.3094)	(–1.9603)	(–.3594)
Japan	1.0967	1.1973	1.1765	1.2097
	(1.5956)	(1.7389)	(.9843)	(.7856)
Netherlands	1.0307	1.0882	.9865	1.0044
	(.5063)	(.7772)	(–.0751)	(.0164)
Switzerland	1.0375	1.0027	1.0059	1.1029
	(.6190)	(.0238)	(.0331)	(.3855)
United Kingdom	1.0654	1.0652	1.0587	1.0710
	(1.0786)	(.5748)	(.3274)	(.2658)
West Germany	1.0526	1.0754	1.0562	1.2689
	(.8676)	(.6645)	(.3131)	(1.0074)

Note: The variance ratios, $1 + M_r(q)$, are reported in the main rows with the heteroscedasticity-robust test statistics, $z^*(q)$, given in parentheses. Under the random walk null hypothesis, the value of the variance ratio is 1 and the test statistic has a standard normal distribution. Test statistic with the asterisk indicates that the corresponding variance ratios are statistically different from 1 at the 5 percent significance level.

and United Kingdom are found not to follow the random walk process for both $q = 8$ and $q = 16$. The returns for Canada and Italy are consistent with the random walk process for $q = 16$, but not for $q = 8$.

For the second subperiod, the number of countries for which the stock returns are found not to behave in the random walk fashion for both $q = 8$ and $q = 16$ increases to three—Australia, Belgium, and West Germany.

Thus Belgium's stock returns are not behaving in the random walk fashion for both subperiods. It can be also inferred that the rejection of the random walk hypothesis for Australia in Table 2 is due primarily to the second half of sample period.

ii. Results for a Four-week Base Observation Period

Next, variance ratio test is conducted for all ten countries with a base observation period of four weeks. Table 5 presents the results using the four-week base observation period. It is found that the random walk hypothesis cannot be rejected for all ten countries at higher values of q.

This finding is consistent with those of Lo and MacKinlay (1988) and Poterba and Summers (1988) who cannot reject the random walk hypothesis for the monthly returns in the U.S. and foreign equity markets, respectively.

4. CONCLUSION

In this study, the random walk hypothesis is tested for the stock markets of ten industrialized countries excluding the United States. Using the heteroscedasticity-robust variance ratio test, this study finds the stock returns of all countries except Australia and Belgium follow the random walk process. This implies that the weekly returns of these eight countries are serially independent.

When the holding period return is lengthened from one week to four weeks, the random walk hypothesis is not rejected for all ten countries. This implies that the monthly returns of all ten countries are independent of the past returns.

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NOTES

1. Fama and French (1988) show that the first-order autocorrelation coefficient of stock returns becomes increasingly negative as the return horizon increases, reaching its minimum for 3–5 year return period, and then moves toward 0.0 for longer return horizons. They hypothesize that the stock price can be represented as a mix of random walk and slowly decaying stationary components. The increase in negative autocorrelation of returns as horizon increases, they claim, is due to the stationary component. However, random walk component eventually begins to dominate the variation of returns, causing the long-horizon autocorrelations to move toward 0.0.
2. DeBondt and Thaler (1987) find that the percentage by which the previous "losers" outperform the market is higher than that by which the previous "winners" underperform the market. The "overreaction" effect is thus asymmetric. They also observe that most of the abnormal returns, especially for losers, are realized in January, lending support to the notion that the "January" effect is subsumed in the "overreaction" effect.
3. Many widely practiced investment strategies such as those based on price/earnings (P/E) ratio, dividend yield, or the book/market value ratio are considered as variants of contrarian investment strategy.
4. Studies examining the stochastic behavior of financial assets of other industrialized nations

have dealt primarily with the dynamics of exchange rate movements [e.g., Cumby and Obstfeld (1984) and Giovannini and Jorion (1989)].

5. The total market value of the stock exchanges of these ten countries as a percentage of the total world stock market value increased from 40% in 1982 to 56.9% in 1986. Also, the stock market value of these ten countries as a percentage of the U.S. stock market value increased from 70.9% to 146% during the same period.

6. Akgiray (1989) finds that a GARCH (Generalized Autoregressive Conditional Heteroscedastic) process best fits the daily returns of both the CRSP value-weighted and equal-weighted indices for the period January 1963 to December 1986. GARCH process specifies the conditional variance of the return, i.e. the variance of the return conditional upon the available information, as a function of the past innovations to the stock returns and past conditional variances.

7. After performing Monte Carlo experiments with 25,000 random sequences of 720 returns, Poterba and Summers (1988) also find that variance ratio tests are not very powerful unless a large number of data is employed.

8. Refer to pg. 62–65 of Lo and MacKinlay (1988) for a detailed proof.

9. Also, Liu and He (1991), employing the Lo and MacKinlay's variance ratio test procedure, reject the random walk hypothesis for five pairs of weekly nominal exchange rates (the Canadian dollars, FF, DM, Yen and Pound, all in terms of the U.S. dollar) over the period from August 7, 1974 to March 29, 1989.

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