THE IMPACT OF DEREGULATION ON STOCK MARKET EFFICIENCY

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This study discusses the gradual shift of the Taiwanese government toward deregulation. Using the traditional variance ratio, nonparametric-based variance ratio tests and a rolling variance ratio test, this study examines the impact of liberalization on market efficiency in Taiwan. The results of the variance ratio test show that the deregulation of the activities of QFIIs is good for Taiwanese market efficiency during the first and third deregulations for foreign investors. Using a fixed-sized rolling window, this study shows that the policy of liberalization helps improve market efficiency, and disproves the weak form of the efficient markets hypothesis. The results of this study have practical implications for regulators wishing to attract international capital into their market in order to help improve market efficiency in emerging markets.

JEL: C14, G14, G18

KEY WORDS: variance ratio tests, rolling variance ratio test, foreign deregulation

INTRODUCTION

The weak-form efficient markets hypothesis (EMH) has been an important issue for individual investors, institutional investors, and government regulators. Harvey (1995) found that the equity returns of emerging markets are highly predictable, and therefore less efficient than those of developed markets. Lima and Tabak (2004) also showed that market liquidity and capitalization may affect market efficiency, since regulators anticipate providing efficient markets to traders in order to attract international capital into markets and encourage economic growth. Kawakastsu and Morey (1999) found that financial market liberalization improves efficiency. Based on the above, governments have implemented a policy of liberalization to attract foreign capital, regardless of whether the liberalized policy facilitates market efficiency.

The Taiwanese government has in the past implemented a sequence of policies to allow qualified foreign institutional investors (QFIIs) to directly invest in its markets. The gradual deregulation of such foreign investment can be divided into three major periods. First, the government began a securities market internationalization program on December 28, 1980. Second, the gradual deregulation of the activities of foreign investors and overseas Chinese investors in 1996 further enhanced the globalization of the Taiwanese stock market. Finally, the government fully removed the limits on QFIIs in October 2003. Mun and Kee (1994), Chang and Ting (2000) and Hoque, Kim and Pyun (2007), however, have shown that market efficiency has been rejected in Taiwan. Since we are interested in considering whether the resulting increase in foreign investor activity has led to the increased efficiency of the Taiwanese stock market, this study investigates the impact of the three deregulations in relation to foreign investment on the efficiency of the Taiwanese stock market.

In the past, large numbers of studies applied much more sophisticated techniques to examine market efficiency (see Lo and MacKinlay, 1988, 1989; Liu and He, 1991; Scheinkman and LeBaron, 1989; Hsieh, 1991; Willey, 1992; Poon and Taylor, 1992; Mun and Kee, 1994; Huang, 1995; Alam, Hasan, and Kadapakkam, 1999; Kawakastsu and Morey, 1999; Opong et al., 1999; Wright, 2000; Ryoo and Smith, 2002; Belaire-Franch and Opong, 2005a, 2005b; Al-Khazali, Ding and Pyun, 2007; Hoque, Kim and Pyun, 2007; Lock, 2007; Hung, Lee and Pai, 2009). Lo and MacKinlay (1988, 1989) used various methods based on the variance ratio test to examine the EMH. It should be noted, however, that Chow and

Denning (1993) pointed out that Lo and MacKinlay (1988, 1989) failed to control the joint-test size that leads to the probability of Type-I errors. Furthermore, Wright (2000) proposed an alternative non-parametric sign and rank-based variance ratio to investigate the EMH; the non-parametric based tests do not rely on the existence of moments and are more robust in the presence of conditional heteroskedasticity.

Only a few studies have not used Wright's (2000) non-parametric variance ratio tests and the multiple test procedure of Chow and Denning (1993) to examine the deregulation of foreign investment in the Taiwanese stock market. In addition, this study applies the fixed-size rolling windows technique based on the Lo and MacKinlay (1988, 1989) and Wright (2000) variance ratio tests to understand the time-varying information of market efficiency following the third deregulation of the Taiwanese stock market. This is because combining the parametric and nonparametric variance ratio tests of Chow and Denning (1993) and the fixed-size rolling windows technique are more powerful and robust when it comes to examining the weak form of the efficient markets hypothesis. Consequently, the study extends the previous research by examining whether the Taiwanese stock market complies with the random walk hypothesis after three deregulations of foreign investment.

The remainder of this article is organized as follows. Section 2 describes the econometric methodology as well as the data. The empirical results are reported in Section 3. The final section contains our conclusions as well as suggestions for further research.

LITERATURE REVIEW

The weak form of efficiency has become an interesting topic and a large number of studies have investigated this issue. Lo and Mackinlay (1988) developed the variance ratio test to examine whether a series follows a random walk process or not. However, as Chow and Denning (1993) have indicated, the analysis by Lo and MacKinlay (1988, 1989) has led to the probability of Type-I errors, and therefore many researchers apply the multiple variance ratio test by Chow and Denning (1993) to examine the weak form of efficiency. Recently, Wright (2000) has developed non-parametric based tests that do not rely on the existence of moments and are more robust in the presence of conditional heteroskedasticity. We therefore focus on the literature on efficiency in the Taiwan stock market and on liberalization.

Mun and Kee (1994) used daily and weekly data from 1982 to 1991 and applied the variance ratio test and spectral shape test to data for Hong Kong, Korea, Thailand, Malaysia and Taiwan. They found that all countries using daily data rejected market efficiency and only Malaysia and Thailand that used weekly data rejected market efficiency. Huang (1995) used daily and weekly data from 1988 to 1992 to perform the variance ratio test and ADF test for Hong Kong, Indonesia, Korea, Japan, Philippines, Singapore, Thailand and Taiwan. They found that the markets for Korea, Malaysia, Hong Kong, Singapore and Thailand were not efficient in their weak form. Alam, Hasan, and Kadapakkam (1999) used data from 1986 to 1995 to examine five Asian markets (Bangladesh, Hong Kong, Malaysia, Sri Lanka, and Taiwan), and concluded that all the stock markets followed a random walk except for Sri Lanka. Kawakastsu and Morey (1999) used monthly data from 1976 to 1997 and performed the variance ratio test, Chow-Denning multiple variance ratio test and ADF test for Korea, Malaysia, the Philippines, Taiwan and Thailand while studying the effect of financial liberalization on the efficiency of emerging equity markets, and found little evidence that financial market liberalization improves efficiency.

Chang and Ting (2000) used weekly, monthly, quarterly and yearly data for Taiwan covering the period from 1971 to 1996 and performed the variance ratio test. They found that for Taiwan market efficiency was rejected, but when lower frequency data was used the market efficiency was not rejected. Ryoo and Smith (2002) used daily data from 1988 to 1998 for Korea and performed the Chow-Denning multiple variance ratio test. They found that the Korean stock market followed a random walk process since the market approached a random walk when the price limits were relaxed. Lima and Tabak (2004) used daily data from 1992 to 2000 for China, Hong Kong and Singapore and performed the Chow-Denning multiple variance ratio to test the random walk hypothesis, and found that the data for China and Singapore rejected the efficient markets hypothesis. Liquidity and market capitalization were, however, found to affect the market efficiency based on their findings for different classes of shares in the Chinese, Hong Kong, and Singapore stock markets. Hoque, Kim and Pyun (2007) used weekly data from 1990 to 2004 for eight emerging equity markets in Asia and performed the variance ratio, Chow-Denning multiple variance ratio and Wright's sign tests to re-examine the random walk hypothesis. They found that stock markets follow a random walk in Indonesia, Malaysia, the Philippines, Singapore, and Thailand, but not in the Taiwanese and Korean stock markets. Lock (2007) used weekly data from 1990 to mid-2006 for Taiwan and applied the Lo and MacKinlay variance ratio test to re-examine the random walk hypothesis. They found that the Taiwan stock market followed a random walk.

Several studies have attempted to address the market efficiency of Taiwan markets, and have come up with mixed results. However, Kawakastsu and Morey (1999) found that financial market liberalization improves efficiency. The Taiwan government implemented a sequence of policies to allow direct investment by QFII. Therefore, this study examines the impact of the three deregulations of foreign investment on Taiwanese stock market efficiency.

METHODOLOGY

In this study, we use the daily returns of the value-weighted stock price index to examine the EMH in relation to the Taiwanese stock market. The sample period extends from January 5, 1970 to December 31, 2008, a period that provides a total of 10,587 observations. The data are obtained from the Taiwan Economic Journal (TEJ) database. The sample return is defined as:

$$R_t = \ln\left(P_t / P_{t-1}\right) \times 100 \tag{1}$$

where R_t and P_t are the return and price at time t.

We apply the traditional variance ratio test and the non-parametric variance ratio test together with the multiple-variance ratio test of Chow and Denning (1993) to examine the EMH for the Taiwan stock market. The variance ratio test of Lo and MacKinlay (1988, 1989) assesses the proportionality of the variance of *k*-differences from the first difference of the series. Lo and MacKinlay found that, for a random walk series, the variance of its *k*-differences is *k* times the variance of its first difference. The variance ratio of the k^{th} difference is defined as:

$$VR(k) = \frac{\sigma^2(k)}{\sigma^2(1)} \tag{2}$$

where $VR(k)$ is the variance ratio of the k^{th} difference of the series; $\sigma^2(k)$ is the unbiased estimator of $1/k$ of the variance of the k^{th} difference of the series under the null hypothesis; $\sigma^2(1)$ is the variance of the first-difference of the series; and k is the number of days in the observation interval, or difference interval. The estimator of the *k*-period difference, $\sigma^2(k)$, can be computed as:

$$\sigma^2(k) = \frac{1}{Tk}\sum_{t=k}^{T}(z_t + ... + z_{t-k-1} - k\hat{\mu})^2 \tag{3}$$

where $\hat{\mu} = \frac{1}{T}\sum_{t=1}^{T} z_t$. The unbiased estimator of the variance of the first difference, $\sigma^2(1)$, is calculated as:

$$\sigma^2(1) = \frac{1}{T}\sum_{t=1}^{T}(z_t - \hat{\mu})^2 \tag{4}$$

The test statistic $M_1(k)$ is therefore defined as:

$$M_1(k) = \frac{VR(k) - 1}{\phi(k)^{1/2}} \tag{5}$$

Under the assumption of homoskedasticity, $M_1(k)$ is asymptotically distributed to N (0, 1), with the asymptotic variance, $\phi(k)$, being defined as:

$$\phi(k) = \frac{2(2k-1)(k-1)}{3kT} \tag{6}$$

The test statistic $M_2(k)$ is robust under heteroskedasticity and is defined as:

$$M_2(k) = \frac{VR(k) - 1}{\phi^*(k)^{1/2}} \tag{7}$$

where $\phi^*(k) = \sum_{i=1}^{k-1}\left[\frac{2(k-i)}{k}\right]^2 \delta(i)$, and $\delta(i) = \frac{\sum_{t=i+1}^{T}(Z_t - \hat{\mu})^2 (z_{t-i} - \hat{\mu})^2}{\left[\sum_{t=1}^{T}(Z_t - \hat{\mu})^2\right]^2}$.

Wright (2000) proposed the use of signs and ranks to substitute for the differences in the Lo and MacKinlay tests, demonstrating that, for some processes, the non-parametric variance ratio tests based on ranks (R_1 and R_2) and signs (S_1) can reject the violations of the random walk hypothesis far better than the tests proposed by Lo and MacKinlay. The R_1 and R_2 proposed by Wright (2000) are defined as follows:

$$R_1 = \left(\frac{\frac{1}{Tk}\sum_{t=k}^{T}(r_{1t} + ... + r_{1t-k+1})^2}{\frac{1}{T}\sum_{t=1}^{T} r_{1t}^2} - 1 \right) * \phi(k)^{-1/2} \tag{8}$$

$$R_2 = \left(\frac{\frac{1}{Tk}\sum_{t=k}^{T}(r_{2t} + ... + r_{2t-k+1})^2}{\frac{1}{T}\sum_{t=1}^{T} r_{2t}^2} - 1 \right) * \phi(k)^{-1/2} \tag{9}$$

where $r_{1t} = \left(r(z_t - \frac{T+1}{2} \right) \Big/ \sqrt{\frac{(T-1)(T+1)}{12}}$ $\quad r_{2t} = \Phi^{-1} r(z_t)/(T+1)$;

$\phi(k)$ is as defined in Equation (9); $r(z_t)$ is the rank of z_t among $z_t, \ldots, z_T$; and Φ^{-1} is the inverse of the standard normal cumulative distribution function. The test based on the signs of the returns is defined as:

$$S_1 = \left(\frac{\frac{1}{Tk}\sum_{t=k}^{T}(s_t + ... + s_{t-k+1})^2}{\frac{1}{T}\sum_{t=1}^{T} s_t^2} - 1 \right) * \phi(k)^{-1/2} \tag{10}$$

where $s_t = 2\mu(z_t, 0)$, $u(z_t, q) = \begin{cases} 0.5 & \text{if} \quad z_t > q \\ -0.5 & \text{otherwise} \end{cases}$; S_1 therefore assumes a zero drift value.

This study uses the multiple variance ratio test by Chow and Denning (1993) to ascertain the degree of autocorrelation and heteroskedasticity in the returns. Based upon the single variance ratio test, Chow and Denning (1993) computed the variance ratio covering all possible intervals. They therefore demonstrated that the multiple variance ratios can generate a procedure for compound comparisons of the set of variance ratio estimates with unity. Consider a set of m variance ratio tests, $\{h(k_j) \mid j = 1,2,\cdots, m\}$, in which there are multiple sub-hypotheses under the random walk null hypothesis; that is:

$$H_{0j} : h(k_j) = 0 \quad for \quad j = 1\cdots, m$$
$$H_{0j} : h(k_j) \neq \quad for\ any \quad j = 1\cdots, m$$

If one or more H_{0j} is rejected, then the random walk hypothesis is also rejected. Since the random walk null hypothesis will be rejected if any of the estimated variance ratios is significantly different from 1, it is therefore necessary to focus only on the maximum absolute value in the set of test statistics. The Chow and Denning (1993) multiple-variance ratio test is based on the results:

$$PR\left[\max(\left|h(k_1)\right|,\cdots,\left|h(k_m)\right| \leq SMM(\alpha;m;T)\right] \geq 1-\alpha \tag{11}$$

where $h(k_q) = \{M_1(k_q),\ M_2(k_q),\ R_1(k_q),\ R_2(k_q),\ S_1(k_q)\}$, $SMM\ (\alpha; \infty;\ \ T\ )$ is the upper α point of the 'standardized maximum modulus' (*SMM*) distribution with m parameters (the number of variance ratios) and T (sample size) degrees of freedom. Asymptotically, when T is infinite:

$$SMM(\alpha;m;\infty) = Z_{\left(1-(1-\alpha)^{1/m}\right)/2} \tag{12}$$

where $Z_{\left(1-(1-\alpha)^{1/m}\right)/2}$ follows a standard normal distribution.

The size of the multiple-variance ratio test is controlled by comparing the calculated values of the standardized test statistics using the *SMM* critical values proposed by Miller (1981); for large samples, these can also be generated from the standard normal distribution using Equation (12). If the maximum absolute value of $h(k_q)$ is greater than the *SMM* critical value at a predetermined significance level, then the random walk hypothesis is rejected.

EMPIRICAL RESULTS

Table 1 reports the preliminary analysis of the returns. The sample mean of the returns is 0.004. The returns exhibit significant skewness and kurtosis against the normal distribution. As indicated by the Jarque-Bera (1987) test statistics, the returns are not normally distributed, demonstrating that the distributions are both leptokurtic and fat-tailed. The Ljung-Box Q(10) and $Q^2(10)$ statistics indicate that the returns and the squared returns both exhibit serial correlation with linear time dependence. The time series plots for price and volume are depicted in Figure 1. We found that volume gradually increases after deregulation takes place.

Table 1: Basic Statistics

Mean	Standard Error	Skewness	Kurtosis	Jarque-Bera	LQ(10)	$LQ^2(10)$
0.0342	1.6122	-0.2172***	2.3385***	2495.3404***	187.845***	16560.121***

*1. *** indicate significance at level of 1%.*

2. Sample Skewness and Kurtosis are $\frac{n(n+1)}{(n-1)(n-2)(n-3)}\sum_{i=1}^{n}[(\frac{x_i-\mu}{\sigma})]^4$ *and* $\frac{n}{(n-1)(n-2)}\sum_{i=1}^{n}[(\frac{x_i-\bar{x}}{S})]^3$ *, respectively.*

3. LQ(10) and $LQ^2(10)$ *refer to the Ljung–Box Q statistics for the return series and squared return series, respectively.*

4. Jarque-Bera test indicate that the normality hypothesis for the distribution of series.

Figure 1: Price and Volume (Ⅰ, Ⅱ and Ⅲ Are Three Deregulation Periods)

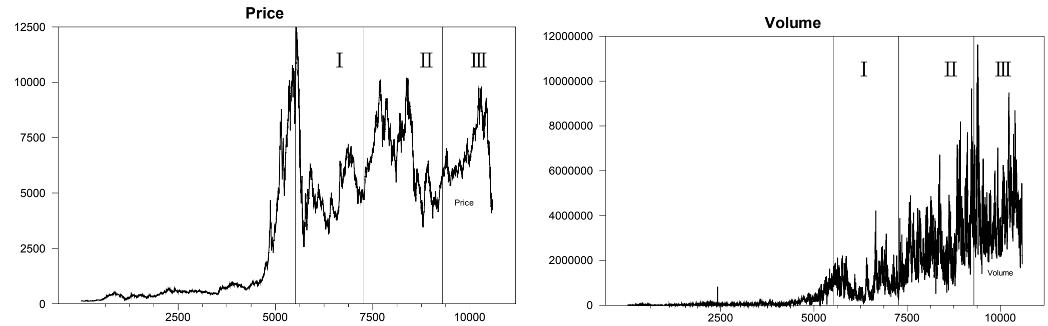


Table 2 reports the results of the variance ratio statistics (M_1, M_2, R_1, R_2 and S_1) for five time intervals (k = 2, 4, 8, 16 and 32 days) using daily data in all samples. The test statistic values of M_1, M_2, R_1, R_2 and S_1 are rejected by all of the test statistics for all time intervals. To avoid obtaining ambiguous conclusions, the multiple variance ratio test of Chow and Denning (1993) was implemented to avoid Type-I errors. Chow and Denning (1993) used the critical values of the SMM distribution to control the overall test size for the single variance ratio test statistics under different time intervals. This investigation further applied the SMM test of Chow and Denning (1993) and found that the M_1, M_2, R_1, R_2 and S_1 tests could be sufficient evidence to reject the random walk hypothesis for all investment horizons with 99% confidence intervals for all samples.

We divided the sample data into two parts, namely, the pre-deregulation period from 1970 to 1990 and the post-deregulation period from 1990 to 2008. Before local markets were deregulated for investment by foreigners, the random walk hypothesis was rejected for all investment horizons for the M_1, M_2, R_1, R_2 and S_1 statistics as well as the SMM at the 1% level of significance in Panel A of Table 3. The results indicated there was no EMH before the deregulation took place. After deregulation, only M_2, which was heteroskedastic, showed that the random walk hypothesis is not rejected for all horizons in Panel B of Table 3. However, we found that, after deregulation, the values of M_1, M_2, R_1, R_2 and S_1 and the SMM decreased to lower levels than they were before the deregulation took place. These results imply that the Taiwanese stock market gradually tended toward the EMH after deregulation took place. Therefore, this study further examines the EMH for the three periods in which deregulation took place.

The results for M_1 and M_2 suggest that the random walk hypothesis for the first deregulation period is not rejected for all levels of k in Panel A of Table 4. In addition, the results of the nonparametric test based on ranks (signs) show that the random walk hypothesis is not rejected, except for k = 4 and 32 (32) of R_1 and R_2 (S_1). Regarding the different outcomes for all variance ratio tests, in this study we applied the SMM test and found that the M_1, M_2, R_1, R_2 and S_1 tests could be supported by not rejecting the random walk hypothesis for which the return series is found to support the EMH in Panel A of Table 4. The first deregulation, which allowed QFIIs to invest with a total quota ceiling, was good for Taiwanese market efficiency.

Table 2: Estimates of Variance Ratio Statistics for All Sample

Periods	Statistics	Number k of base observations forming variance ratio					SMM
		2	4	8	16	32	
All Sample (1971/1/1-2008/12/31)	M_1	9.1***	10.84***	8.82***	8.27***	7.81***	10.84***
	M_2	4.61***	5.43***	4.41***	4.16***	4.01***	5.43***
	R_1	6.25***	8.57***	8.25***	8.99***	10.08***	10.08***
	R_2	7.3***	9.52***	8.45***	8.6***	9.06***	9.52***
	S_1	4.06***	6.54***	8.36***	10.57***	12.57***	12.57***

*Note: 1. ***, ** and * indicate significance at the 1, 5 and 10 percent levels respectively.*
2. Significance at 10%, 5% and 1% of SMM are 2.31066, 2.56876 and 3.08904, respectively.
3.The test statistic $M_1(k)$, $M_2(k)$, $R_1(k)$, $R_2(k)$, $S_1(k)$ are defined as $\left(VR(k)-1\right)/\left(\phi(k)^{1/2}\right)$, $\left(VR(k)-1\right)/\left(\phi^*(k)^{1/2}\right)$, $\left[\left(\sum_{t=k}^{T}(r_{1t}+\ldots+r_{1t-k+1})^2/Tk\right)/\left(\sum_{t=1}^{T}r_{1t}^2/T\right)-1\right]*\phi(k)^{-1/2}$, $\left[\left(\sum_{t=k}^{T}(r_{2t}+\ldots+r_{2t-k+1})^2/Tk\right)/\left(\sum_{t=1}^{T}r_{2t}^2/T\right)-1\right]*\phi(k)^{-1/2}$ *and* $\left[\left(\sum_{t=k}^{T}(s_t+\ldots+s_{t-k+1})^2/Tk\right)/\left(\sum_{t=1}^{T}s_t^2/T\right)-1\right]*\phi(k)^{-1/2}$*, respectively.*

Table 3: Estimates of Variance Ratio Statistics for Pre- and Post- Deregulations

Periods	Statistics	Number k of base observations forming variance ratio					SMM
		2	4	8	16	32	
Pre-Deregulation (1971/1/1-1989/12/28)	M_1	12.69***	14.02***	13.32***	13.05***	11.29***	14.22***
	M_2	4.02***	4.5***	4.29***	4.23***	3.73***	4.58***
	R_1	10.63***	13.2***	14.89***	15.9***	15.43***	15.9***
	R_2	12.00***	14.30***	15.08***	15.52***	14.13***	15.55***
	S_1	4.83***	7.08***	10.00***	12.47***	14.31***	14.31***
Post-Deregulation (1990/1/1-2008/12/31)	M_1	2.94***	4.03***	2.14**	1.72*	2.15**	4.03***
	M_2	1.38	1.87*	0.99	0.8	1.02	1.87
	R_1	1.65	2.83***	1.82*	2.18**	3.47***	3.47***
	R_2	2.05*	3.24***	1.85*	1.86*	2.91***	3.24***
	S_1	0.72	1.92*	1.4	1.99*	2.93***	2.93**

*Note: 1. ***, ** and * indicate significance at the 1, 5 and 10 percent levels respectively.*
2. Significance at 10%, 5% and 1% of SMM are 2.31066, 2.56876 and 3.08904, respectively.
3.The test statistic $M_1(k)$, $M_2(k)$, $R_1(k)$, $R_2(k)$, $S_1(k)$ are defined as $\left(VR(k)-1\right)/\left(\phi(k)^{1/2}\right)$, $\left(VR(k)-1\right)/\left(\phi^*(k)^{1/2}\right)$, $\left[\left(\sum_{t=k}^{T}(r_{1t}+\ldots+r_{1t-k+1})^2/Tk\right)/\left(\sum_{t=1}^{T}r_{1t}^2/T\right)-1\right]*\phi(k)^{-1/2}$, $\left[\left(\sum_{t=k}^{T}(r_{2t}+\ldots+r_{2t-k+1})^2/Tk\right)/\left(\sum_{t=1}^{T}r_{2t}^2/T\right)-1\right]*\phi(k)^{-1/2}$ *and* $\left[\left(\sum_{t=k}^{T}(s_t+\ldots+s_{t-k+1})^2/Tk\right)/\left(\sum_{t=1}^{T}s_t^2/T\right)-1\right]*\phi(k)^{-1/2}$*, respectively.*

Table 4: Estimates of Variance Ratio Statistics for Three Deregulations

Periods	Statistics	Number k of base observations forming variance ratio					SMM
		2	4	8	16	32	
First Deregulation (1990/1/1-1996/3/2)	M_1	1.2	1.59	0.91	0.02	0.69	1.59
	M_2	0.27	0.36	0.2	0.01	0.16	0.36
	R_1	0.86	1.72*	1.41	1.44	2.23**	2.23
	R_2	0.9	1.72*	1.33	1.05	1.87*	1.87
	S_1	0.52	1.36	1.32	1.48	1.95*	1.95
Second Deregulation (1996/3/3-2003/10/1)	M_1	2.45***	3.42***	2.09**	1.77*	1.57	3.42***
	M_2	0.96	1.33	0.81	0.7	0.63	1.33
	R_1	2.04**	2.7***	2.01**	2.13*	2.84***	2.84**
	R_2	2.22**	3.00***	1.99**	1.91*	2.39***	3.00**
	S_1	1.51	2.25**	1.74*	1.99*	2.47***	2.47*
Third Deregulation (2003/10/2-2008/12/31)	M_1	0.94	1.22	0.13	0.52	1.03	1.22
	M_2	0.22	0.28	0.03	0.12	0.24	0.28
	R_1	-0.56	-0.05	-0.75	-0.21	0.46	0.46
	R_2	-0.15	0.31	-0.55	-0.11	0.44	0.44
	S_1	-1.11	-0.67	-0.97	-0.31	0.16	0.16

*Note: 1. ***, ** and * indicate significance at the 1, 5 and 10 percent levels respectively.*

2. Significance at 10%, 5% and 1% of SMM are 2.31066, 2.56876 and 3.08904, respectively.

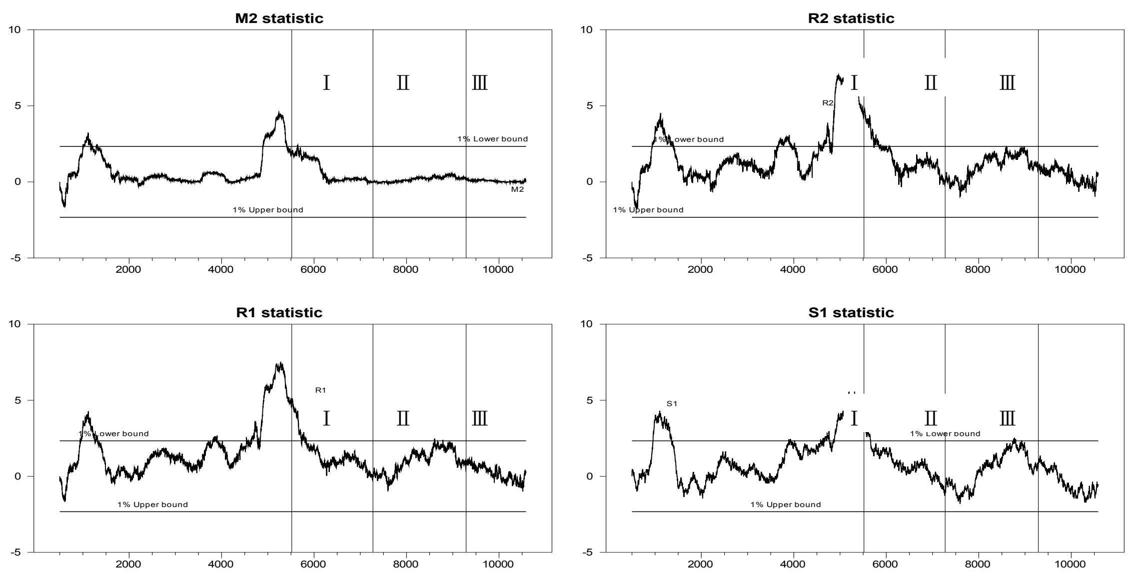
3. The test statistic $M_1(k)$, $M_2(k)$, $R_1(k)$, $R_2(k)$, $S_1(k)$ are defined as $(VR(k)-1)/(\phi(k)^{1/2})$, $(VR(k)-1)/(\phi^*(k)^{1/2})$, $\left[\left(\sum_{t=k}^{T}(r_{1t}+...+r_{1t-k+1})^2 \Big/ Tk\right)\Big/\left(\sum_{t=1}^{T} r_{1t}^2 \Big/ T\right)-1\right] *\phi(k)^{-1/2}$, $\left[\left(\sum_{t=k}^{T}(r_{2t}+...+r_{2t-k+1})^2 \Big/ Tk\right)\Big/\left(\sum_{t=1}^{T} r_{2t}^2 \Big/ T\right)-1\right] *\phi(k)^{-1/2}$ *and* $\left[\left(\sum_{t=k}^{T}(s_t+...+s_{t-k+1})^2 \Big/ Tk\right)\Big/\left(\sum_{t=1}^{T} s_t^2 \Big/ T\right)-1\right] *\phi(k)^{-1/2}$, *respectively.*

The results for M_1 suggest that the random walk hypothesis is not supported by any level of k in Panel B of Table 4, with the exception of k=32 for the second deregulation period. However, the results for M_2 suggest that the random walk hypothesis should not be rejected in the case of the second deregulation period. Due to the different outcomes between M_1 and M_2, this study applies further nonparametric tests based on ranks and signs for R_1, R_2 and S_1 to test the random walk hypothesis. The results for R_1, R_2 and S_1 reject the random walk hypothesis for all levels of k. In addition, from the SMM test we found that the M_1, R_1, R_2 and S_1 tests can be supported by the rejection of the null, except for M_2 in Panel B of Table 4. The second deregulation, which allowed foreign nationals to invest, was not helpful to Taiwanese market efficiency.

Finally, the results for M_1, M_2, R_1, R_2, S_1 and the SMM indicate that the random walk hypothesis is not rejected at any level of k in Panel C of Table 4 for the third deregulation period. As a result of the Executive Yuan's amendment of the "Regulations Governing Investment in Securities by Overseas Chinese and Foreign Nationals," in which the QFII system was abolished, all foreign investors can, without needing to obtain permission from the Securities and Futures Commission, invest in the securities market after simply registering with the Taiwan Stock Exchange Corporation and obtaining an investment license. Therefore, the third deregulation, which has allowed QFIIs to invest without any total quota ceiling, has been good for Taiwanese market efficiency.

Since the sample used in this study covers quite a long period, we are interested in knowing if the results of the study in terms of market efficiency would be the same for a short-term sampling. In addition, structural changes or outliers, which are caused by financial catastrophes or changes in the regulatory regime, might adversely affect the performance of statistical tests. To this end, this investigation has used a fixed-sized rolling window to compute time-variant statistical values that may provide a more detailed perspective of market efficiency. Figure 2 shows the plots of the multiple variance ratio test statistical values (M_2, R_1, R_2 and S_1) using fixed-size rolling windows of 500 observations.

Figure 2: Taiwan Returns. Application of the M_2, R_1, R_2 and S_1 Tests at Lag 2, Using a Rolling Window of 500



Observations. The Horizontal Lines are the corresponding 1% critical values.

For fixed-size rolling windows with similar results, we display only the graphs for Wright (2000) for lags of $k = 2$. In Figure 2, the statistical values of M_2, R_1, R_2 and S_1 almost lie outside (within) the horizontal lines for the 1% critical value before (after) QFII deregulation. These results show that the policy of liberalization has helped market efficiency. During the first and second deregulation periods, the statistical values of R_1, R_2 and S_1 are less outside the horizontal lines for the 1% critical value. The statistical values of M_2, R_1, R_2 and S_1, however, do not lie outside the horizontal lines for the 1% critical value during the third period. This result confirms the weak-form EMH after the QFII system was abolished. These results imply that the time-varying results are consistent with those of the previous section.

CONCLUSION

This study has examined the behavior of the Taiwanese stock market as the government has gradually deregulated foreign investment, by using the traditional variance ratio, nonparametric-based variance ratio tests and a rolling variance ratio test. The purpose of the investigation has been to determine the impact of government liberalization on market efficiency.

The empirical results indicate that the values of all the statistics and the SMM after deregulation have decreased more than before deregulation, implying that the Taiwanese stock market has gradually tended to support the EMH following deregulation. Moreover, the results indicate that liberalization has helped market efficiency during the first and third deregulation stages, but has not been helpful during the second deregulation stage. By using a fixed-sized rolling window, this study has found that the policy of liberalization has helped market efficiency. Our results support the view that equity markets should become more efficient if they are opened up to international investors. This finding has practical implications for regulators wishing to attract international capital into their markets to help improve market efficiency in emerging markets.

There shortcoming limit the generalization of this study is only used Taiwan's data. Therefore, this paper suggests that future research examine EMH using other emerging markets including stock and exchange rate so on when opened up to international investors. Other specific applications may require special considerations to issues not addressed here.

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