Testing the Weak-Form Efficient Market Hypothesis: Using Panel Data from the Emerging Taiwan Stock Market

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Abstract

This empirical study investigates whether the Taiwan Stock market is weakly efficient by modifying and estimating Dockery and Kavussanos' multivariate model using a set of panel data. The Taiwan equity market is characterized as high-tech, one of the most liquid markets on the globe, well and strictly regulated, and in an advanced emerging economy. However, the empirical findings suggest that the Taiwan stock market is not informationally efficient, which may be attributable to the lack of broadness and depth of the market. The results further indicate that when the number of stocks included in the sample exceeds 5, the null hypothesis of the efficient market hypothesis is rejected throughout.

Keywords: Efficient market hypothesis, panel data, Taiwan Stock Exchange; regression model.

JEL Classification: C01, E32, E44, E51

Introduction

The growth of equity markets and the globalization of financial markets are often the subject of major research studies in developing countries. Additionally, testing different forms of the efficient market hypothesis seems to be the most popular theme of these empirical investigations. Institutional and large investors strive for portfolios with international stocks because of higher potential returns. Even with the 5 percent and 10 percent stipulations in US mutual funds, transactions by these investors are nowhere near odd lot orders. These, in turn, prevent most developing economies from benefiting from recent increases in internationalization of portfolio investments. This phenomenon pushes most developing economies into a downward spiral or a vicious circle because their equity markets are not deep and broad enough. In addition, they lack the necessary infrastructures to attract international portfolio investments. Because they cannot attract the international portfolio investments, their markets cannot be deep and broad and they cannot improve their infrastructures. Information on the characteristics of markets and about listed companies in the equity markets cannot be dissimilated quickly due to insufficient electronic and other infrastructures that render equity markets in developing countries not even weakly efficient.

Although most empirical research is concentrated in the financial markets in developed economies, a few studies suggested that return predictability also existed in those less developed financial markets. Ferson and Harvey (1993) investigated 18 international equity markets, including some in developing economies. Their empirical results revealed evidence of return predictability. Harvey (1995) examined the returns of more than 800 stocks from twenty emerging economies and reported eight hundred emerging markets, including Taiwan, and found that the degree of predictability in the emerging markets is greater than that in the developed markets. Harvey also suggested that local information played a much more important role in predicting returns in the emerging markets than in the developed markets.

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This characteristic helps explain the difference in predictability between the two kinds of markets. Hoque, Kabir, and Rahman (2005) reported that the Bangladeshi and the Indian equity markets show significant mean-reversion and predictable behaviors in their daily return series. However, the authors found that the US and Japanese stock markets exhibit some mean-reversion, but largely follow unpredictable patterns over the 1990-2005 period.

Forbes' (June 1, 1998) article about Taiwan, entitled "Silicon Valley East," noted: Helping make investment attractive is the tremendous liquidity in the system. In 1997 the Taiwan Stock Exchange's (TSE.) trading volume, 90% retail driven, was $1.3 trillion, greater than Tokyo's and the third largest in the world after New York and London. The article further reported that about 30% of Taiwan's population holds stocks, compared with estimates of fewer than 10% in Japan and Korea. More specifically, Ho (2006) indicated that that Stock trading in Taiwan takes place in two exchanges – the Taiwan Stock Exchange (TSE) and the over-the-counter market (OTC). The TSE, established in 1962, is considered as a major stock exchange in Taiwan. Since the requirements of listing on the TSE, such as the minimum capitalization, profitability, and share dispersion, are much more stringent than those on the OTC, firms unqualified for listing on the TSE may choose to list their stocks on the OTC, incepted in 1989, if they meet the listing requirements.

Ho (2006) also posited that the market designs of the TSE and OTC are quite similar. Both markets employ call order-driven auctions in a computerized environment without any involvement from dealers or market makers to execute orders from public investors. Regular trading hours start at 9 a.m. and end at 1:30 p.m. Monday through Friday. During the regular trading hours, the basic lot size at the TSE as well as the OTC is in multiples of 1000. A 7% up/down daily fluctuation limit from the previous closing price is imposed to restrict undue fluctuation. Starting July 1, 2002, the TSE eliminated the two up/down tick rule which stipulates that the intra-day continuous auction prices move within the two up/down ticks of the last executed price. Since the OTC market does not implement this rule, the elimination of the two up/down tick rule in the TSE makes the two markets more alike and comparable.

Both the TSE and OTC are extremely liquid and volatile. Their average annual turnover rates have been over 200 percent in recent years. Stocks of electronics and high-tech companies have dominated these markets, often representing one-third to half of the trading or market capitalization. Also, most listed companies are still family owned and controlled. Claessens (2001, p. 6) examined the direct ownership concentration of Taiwanese listed companies and found the mean block ownership to be 14.89 percent. However, the author believed that the figure would be higher if indirect ownership was included.

As to the listing requirements, Ammermann (1999) pointed out that TSE-listed companies are top quality companies in Taiwan and TSE is one of the world's most heavily traded and highly liquid stock exchanges. Listed companies observe strict disclosure requirements, and must disclose a set of financial and operational information periodically and in a timely fashion, both in print and electronic forms. Failure to do so results in trade suspension of the company's stock. Also, any significant event relevant to a listed company must be announced by the company's authorities or on an electronic bulletin board system within two business days. All of the trades on the TSE are electronically matched and executed and both payments and deliveries are settled on an electronic book-entry basis. TSE claimed that its "T+2" rolling net settlement system is "among the most efficient clearance systems." TSE established a NT$6 billion "mutual responsibility settlement fund" to guarantee the settlement of every trade along with a "securities investors' protection program" to cover an investor's losses up to NT$1 million if he suffers a loss as a result of a broker's default or insolvency.

In light of the aforementioned, the high-tech Taiwan stock market of a very advanced emerging economy is of particular interest for further empirical research. This study differs from previous endeavors in which it modifies Dockery and Kavussanos' multivariate model to allow the use of a set of panel data as a set of pooled data from the Taiwan Stock Exchange market to test the weak-form of the efficient market hypothesis. The investigation also examines the sensitivity of the number of stocks included in the sample to the results. The remainder of the paper is organized as follows: the next section briefly reviews the literature, the section that follows presents the methodology, and reports empirical results, the following section reports and discusses the empirical results, and the final section provides the concluding remarks.

Literature Review

The efficient market hypothesis dates back to when the business cycle theorists tried to analyze the behavior of the stock markets over time in search of indicators of the business cycles. Kendall (1953) examined the stock market behavior, and to his surprise, he could not identify any predictable patterns in the stock prices. Over time, as equities became increasingly important sources of corporate finance, theorists such as Fama (1970) and numerous others began to hypothesize and to empirically test stock price behaviors leading to the formulation of efficient market hypothesis. The two most common procedures for testing efficient market hypothesis are the runs test (DeFusco et al. 2004) and serial correlation analysis (Conrad and Kaul 1988, Lo and McKinlay 1988).

The correlation analysis tests for the significance of positive or negative correlations in stock returns over time. Specifically, the correlation tests for independence, i.e., random walk, by statistically determining whether the rate of return on day *t* correlates to the return on day *t-1, t-2,* or *t-3*. The runs test examines a series of stock price changes and these changes are designated a plus (+) if it is an increase in price or a minus (-) if it is a decrease in price. The result is a set of pluses and minuses. A run occurs when two consecutive changes are the same: two or more consecutive positive or negative changes are defined as one run. When the price changes in a different direction, such as when a negative price change is followed by a positive price change, the run ends and a new run may begin. To test for random walk, the number of runs for a given series is compared to a table of expected values for the number of runs that should occur in a random series.

Empirical studies using these testing procedures have yielded mixed results. Historically, earlier evidence was quite favorable to the hypothesis, but in recent years, deeper analyses of evidence cast doubt on their validity as a whole. The following are taken as evidence in favor of the efficient market hypothesis. The investments in mutual funds cannot be expected to earn an abnormally high return. Good performance in the past does not guarantee that the investment advisor or a mutual fund will perform well in the future. Favorable earnings announcements or announcements of stock splits do not, on average, cause stock price to increase. Future changes in stock prices, for all purposes, are unpredictable. On average, technical analysts do not fare better than other financial analysts, nor do they outperform the market. However, small-firm effect, January effect, market overreaction, excessive volatility, mean reversion, and new information not being immediately incorporated in stock prices are taken as evidence against the efficient market hypothesis.

Dockery and Kavussanos (1996) used a regression model applied to the panel data to test the weak form of the efficient market hypothesis on the Athens Stock Market. Dockery and Kavussanos began by considering a simple regression model where the current stock price is regressed on an intercept constant, the price in the last period, and a disturbance. The authors argued that the necessary condition for the Athens Stock Market to be weakly efficient is that the estimated constant and the estimated coefficient of the past period price cannot be statistically different from 0 and 1, respectively. However, they posited that since the stock prices are not stationary, they have to model their first differences. To this end, periodic changes in stock prices are regressed on an intercept constant and a disturbance. Dockery and Kavussanos articulated that in the new expression, the necessary condition for the market to be weakly efficient is that the estimated intercept constant could not be statistically different from zero.

Methodology

In testing the weak-form of the efficient market hypothesis using panel data from Athens Stock Market, Dockery and Kavussanos defined P_{it} and $P_{i,t-1}$ as the prices of stock *i* at time *t and t-1* and postulated the following regression model:

$$P_{it} = \alpha_i + \rho_i P_{i,t-1} + \varepsilon_{it} \qquad (1)$$

where *i = 1, 2, …….N* and *t = 1, 2,……*I, *N* is number of individual stocks and I is number of observations for stocks. α_i and ρ_i are intercept and slope constants, respectively. ε_{it} is a Gaussian error term which may exhibits contemporaneous correlation between stocks. The weak efficient market hypothesis may be stated as:

$$H_0: \quad \rho_i = 1 \text{ and } \alpha_i = 0 \qquad H_a: \quad \rho_i \neq 1 \text{ and } \alpha_i \neq 0$$

Dockery and Kavussanos (1996, p. 122) argued that "it is usually the case that stock prices are non-stationary, in which case in order to avoid inference problems stock returns are considered".

The authors defined the stock returns as the differences between the logarithmic values of the stock prices prevailing in the current period and the last period, and rewrote their regression equation as:

$$r_{it} = \alpha_i + \varepsilon_{it} \quad (2)$$

where *i = 1, 2, …….N and t = 1, 2,……T.* They posited that the weak efficient market hypothesis becomes:

$$H_0: \ \alpha_i = 0 \qquad H_a: \ \alpha_i \neq 0$$

Expression (2) is a system of *N* equations with cross equation correlations allowed in the residuals. Dockery and Kavussanos (1996) articulated that the seemingly unrelated estimation procedure, proposed by Zeller (1962), would yield more efficient parameter estimates than the ordinary least squares method. A Wald test statistics, using only the unrestricted model (2), can be used to test the set of null and alternate hypotheses of the efficient market hypothesis. Let $h(a) = 0$ be the set of restrictions, given a vector of estimates *a*, the associated covariance estimate $V(a)$, and the covariance matrix of the restricted $V[h(a)] = (\partial h / \partial a)' V(a)(\partial h / \partial a)$, the Wald test statistics, evaluated at the unrestricted estimate *a* is:

$$W = h(a)V[h(a]^{-1} h(a)' \quad (3)$$

This test statistics has an asymptotical Chi-squared distribution with the degrees of freedom equal to the number of restrictions (Dockery and Kavussanos 1996, p. 122).

In formulating their model, specified by equation (2), Dockery and Kavussanos (1996) defined r_{it} as the difference between the logarithmic values of the stock prices in the current period and the previous period. Therefore, the value of r_{it} for any stock *i* is inevitably affected by the price level of that stock, as measured by the unit of currency. Because of the difference in their prices, the same percentage change in the prices of two stocks traded in the previous day would result in two different quantity changes. To account for this difference, Dockery and Kavussanos (1996) used the multivariate model in which each stock included in the sample is modeled and estimated by one of the equations in the system. However, most of the financial reports on changes in stock prices are in percentage changes from one period to another. If the return is expressed in terms of percentage change, then it can be interpreted as the return on one unit of currency invested in a stock, magnified one hundred times; therefore, the impact of the price level is removed from it. As a result, different magnitudes of daily changes reflect only the impact of the good or bad news about the stock, excluding the impact of price level prevailing at the end of the last period.

Let s_{it} be the percentage change from $P_{i,t-1}$ to P_{it} where P_{it} and $P_{i,t-1}$ are the prices of stock *i* at time *t and t-1,* then equation (2) can be *rewritten* as:

$$s_{it} = \delta_i + \upsilon_{it} \quad (4)$$

where *i = 1, 2, ……N and t = 1, 2,……T;* δ_i, υ_{it} are respectively an intercept constant and a Gaussian error term which may exhibits contemporaneous correlation between the stocks. Equation (4) is of a univariate nature which can be estimated using all data points in the panel data set as the set of pooled data. The hypothesis for the weak efficient market hypothesis may be stated as:

$$H_0: \ \delta_i = 0 \text{ and} \qquad H_a: \ \delta_i \neq 0 \quad (5)$$

Wald test statistics using only the unrestricted model (4) can be used to test the set of null and alternate hypotheses of the efficient market hypothesis with only one restriction. Thus the asymptotical Chi-squared has one degree of freedom.

Data

This empirical investigation utilizes daily data from the TSE, for the months of January and February of 2008, May and June of 2009 and November and December of 2010. These dates are randomly selected and they provide a total of 121 trading days (22 days in January 2008, 14 days in February 2008, 18 days in May 2009, 22 days in June 2009, 22 days in November 10, and 23 days in December 2010). Among the stocks listed on TSE, only 633 of them were traded in every day of the 121 trading days.

For convenient electronic transportation of data among the authors, this study randomly selected a sample of 540 of these stocks for its empirical analysis. This yields 63,340 panel data points (540 stocks x 121 days) that can be pooled. The calculated daily percentage changes on returns on the stocks were used to estimate the model specified by equation (4).

Empirical results

This section examines the empirical findings on whether or not the Taiwanese stock market is demonstrating weak efficiency. Specifically, equation (4) is estimated using the percentage changes in the prices of 540 sample stocks for the randomly selected months of January and February of 2008, May and June of 2009, and November and December of 2010. The calculated Chi-squared test statistic and the p-value are reported in Table 1. Based on the calculated Chi-squared statistic with one degree of freedom of 296,037.8636, the null hypothesis of the weak-form of the efficient market hypothesis should be rejected at any conventional level of significance. This rejection strongly suggests that the Taiwanese stock market has not been informationally efficient, despite being one of the most technologically sound, stringently regulated, liquid markets on the globe.

The aforementioned technological sterilization, regulation, investor protection, and trading volumes of the Taiwan equity market had been close to that one of the very advanced neighboring country—Japan. Specifically, the heavy trading of the Taiwanese investors has enabled the TSE to challenge the U.S. and Japanese stock markets for the position of world's largest stock market in terms of daily trading volume in the 1990s. Also, as reported by Hoque, Kabir, and Rahman (2005), the US and Japanese stock markets exhibit some mean-reversion, but largely followed unpredictable patterns over the 1990-2005 period. This study strongly suggests that the Taiwan equity market is not suffering from weak efficiency. Perhaps noting the following characteristics of the Taiwan equity market can put the empirical results in better perspective.

The Taiwan economy is an advanced emerging market, but it considerably smaller compared to the U.S. and Japanese markets. Therefore, there are not as many firms in the economy and these firms cannot be as large as those in the U.S. and Japan. Consequently, their market capitalization as well as the Taiwan market capitalization cannot be as large as those in the U.S. or Japan. Thus, it is logical to speculate that the large daily trading volumes in Taiwan equity market are the aggregate of many small orders. The Taiwanese government's decision to phased out restrictions preventing foreign investors from trading in its equity market coupled with the recent internationalization of investors from developed economies, institutional or otherwise, have drastically increased the size of market orders in the TSE. Consequently, the Taiwan equity market displays excessive volatility; that is, fluctuations in stock prices may be much greater than is warranted by fluctuation in their fundamental value. This phenomenon may be one important factor which limits stock markets which are not broad and deep from developing and emerging economies such as the Taiwanese market from being efficient.

Table 1: Wald test statistic and p-value

$\chi^2_{(1)}$ *value*	296,037.8636
p-value	*0.0000*

One of the issues in applied statistics is the question of how representative the samples are. The issue is more relevant when researchers do not have much flexibility in selecting their samples. The sample used in this empirical investigation is an example of this. Out of almost seven hundred and fifty stocks traded on the TSE — only six hundred and thirty three of these stocks traded every day in the one hundred and twenty one trading days in the randomly selected months of January and February of 2008, May and June of 2009 and November and December of 2010. If a longer period were selected, the number of stocks which are traded every day would be even lower.

Table 2: Wald statistics for various numbers of stocks

Number of stocks in the sample	$\chi^2_{(1)}$ *statistic*	*p-value*
5	2,597.1373	0.0000
10	5,940.9424	0.0000
20	11,619.2777	0.0000
30	17,612.8066	0.0000
60	2,163.7345	0.0000
180	92,495.5131	0.0000
300	165,429.5898	0.0000
420	224,746.8218	0.0000
540	296,037.8636	0.0000

Therefore, it is of some interest to investigate whether the result reported in Table 1 is sensitive to the number of the stocks selected and how representative they are of the whole Taiwan Stock Exchange. This study performs the cumulative Wald test by including 5, 10, 20, 30, 60, 180, 300, and 420. The results are summarized in Table 2. Analysis of the findings, reported in Table 2, reveals that when the number of stocks in the sample exceeds 5, the weak-form of the efficient market is rejected at any conventional level of significance.

Concluding Remarks and some policy implications

Since the early 1990s, the Taiwan stock market has been characterized as *high-tech, one of the most liquid markets in the globe, well and strictly regulated in an advanced emerging economy.* Moreover, the Taiwan equity market with its heavy trading of the Taiwanese investors has enabled the TSE to challenge the U.S. and Japanese stock markets for the position of world's largest stock market in terms of daily trading volume. The TSE generates large trading volume with a small number of shares listed and only a small proportion of the shares outstanding for any of these listings actually available for trading. This situation is even more remarkable when there are relatively few outside investors in the TSE; thus, virtually all the trading volume is drawn from citizens of Taiwan.

These characteristics have generated enormous intellectual curiosity as to whether the Taiwan equity market is efficient. To probe this curiosity, this study modified and estimated Dockery and Kavussanos' multivariate model using a set of Taiwanese panel data. The empirical findings strongly suggest that Taiwan stock market is not informationally efficient, which may be attributable to the lack of broadness and depth of the stock markets of developing and emerging economies, in general, and the Taiwan economy in particular. The findings further indicate that when the number of stocks included in the sample exceeds 5, the null hypothesis of the efficient market hypothesis is rejected throughout.

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