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PREDICTABILITY OF TECHNICAL TRADING RULES: EVIDENCE FROM THE TAIWAN STOCK MARKET

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Abstract: *Using the Taiwan Stock Exchange Weighted Index from the first trading day in 1975 to the last trading day in 2007, we investigate the predictability of two popular technical rules (variable-length moving average and trading range breakout) in the Taiwan stock market and assess its bearing on market efficiency. Our results show that, for the two rules, returns from buy signals are generally higher than those from sell signals. In addition, they exhibit considerable predictive power over 1975-1985 and 1986-1996 but become less effective over 1997-2007. These results suggest that the financial reform and liberalization measures (particularly the QFII system) implemented since the early 1990s have contributed, to a certain extent, to the improved efficiency of the Taiwan stock market.*

JEL Classifications: *G14, G15*

Keywords: *variable-length moving average, trading range breakout, financial reform and liberalization measures*

INTRODUCTION

Technical analysis is the study of historical data to determine future prices on the basis of trends. The first renowned technical analyst was Charles Dow, the creator of the Dow Jones Industrial Average (DJIA), who published his technical analysis in the *Wall Street Journal* in the early 1900s. Dow first applied technical analysis to analyze the two stock market indices he formulated in 1897, namely one index on 20 rails and the other on 12 industrials. However, most of his technical rules are also applicable to other financial instruments, such as individual stocks, futures, options, commodities or any tradable securities where price is determined by supply and demand. As a further extension, Blume *et al.* (1994) use volume or open interest figures in their studies of price movements.

Since the seminal works of Samuelson (1965) and Fama (1965, 1970) on the efficient markets hypothesis (EMH), the role of technical analysis as a forecasting tool has remained to be controversial in the academic literature. According to the EMH (Fama, 1970), a market is efficient if security prices fully reflect all available information. In particular, a market is weak-form efficient if all information contained in historical prices is fully reflected in current prices. The implication of the weak- form EMH is that if the market is weak-form efficient, then technical

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analysis based on an examination of historical price data is worthless. In fact, many early empirical studies (e.g., Alexander, 1964; Fama and Blume, 1966; Van Horne and Parker, 1967; James, 1968; Jensen and Benington, 1970) find little evidence showing technical analysis is useful in helping investors to make abnormal returns. As one of the leading proponents of the EMH, Jensen (1978) claims that "there is no other proposition in economics which has more solid empirical evidence supporting it than the Efficient Markets Hypothesis."

In the last 20 years, however, the EMH and the empirical evidence purporting to support it have been subject to serious challenge. Many studies (e.g., De Bondt and Thaler, 1985; Poterba and Summers, 1988; Lehmann, 1990; Lo and MacKinlay, 1990) provide evidence of predictability of equity returns from historical returns. Widely recognized as the world's greatest investor, Warren Buffett does not believe in efficient markets. He once said (Para, 1995), "I'd be a bum on the street with a tin cup if the market were efficient." In fact, empirical studies (e.g., Sweeney, 1988; Brock *et al.*, 1992; Bessembinder and Chan, 1998; Wong *et al.*, 2003; Metghalchi *et al.*, 2008) have indicated that technical analysis is useful to investors in some developed markets. In particular, Brock *et al.* (1992), using 90-years of daily DJIA data, provide strong support for the moving average (MA) and trading range breakout (TRB) rules. In this study, we examine the efficacy of the MA and TRB rules in the Taiwan stock market — a relatively less developed but fast-growing market in the Asia-Pacific region.

Specifically, we focus on the Taiwan stock market for two reasons. First, financial economists tend to view individual investors as noise traders who, as Black (1986) puts it, "trade on noise rather than information." For example, Barber *et al.* (2006) find that Taiwan's individual investor trading often leads to "systematic and economically large losses." Hence, a market dominated by individuals can hardly be considered efficient. Since individuals account for the great majority of Taiwan's investor population, it is interesting to examine whether some technical rules can be used to exploit profit opportunities in such market environment. Second, since the early 1990s, the Securities and Futures Commission (SFC) of Taiwan has implemented a series of financial reform and liberalization measures intended to improve market efficiency and competitiveness. One major outcome of these measures is that participation of domestic and foreign institutional investors in the local stock market has increased considerably. As a result, have these measures and increasing participation of institutional investors contributed, to a certain degree, to the improved efficiency of the Taiwan stock market? This could, in turn, have an effect on the efficacy of the technical rules.

For implementation, we employ two popular technical rules–variable-length moving average and trading range breakout—to assess their predictability in the Taiwan stock market based on daily closing prices of the Taiwan Stock Exchange Weighted Stock Index (TAIEX) from 1975 to 2007. Our rationale for using them is that if the Taiwan stock market is weak-form efficient, then the two rules, whose trading decisions are based on historical prices, will not lead to abnormal returns. These two rules were used by many researchers (e.g., Brock *et al.*, 1992; Hudson *et al.*, 1996; Bessembinder and Chan, 1995, 1998; Gencay, 1998) to examine their efficacy in some well-known stock markets in the world. In footnote 6, Brock *et al.* (1992) provide some good justification for using these two technical rules:

> Examples of the rules used in this paper can be found more than 60 years ago by influential market participants. For example, the ideas of trading ranges and resistance or support levels can be found in

> Wyckoff (1910). More "recent" references to these techniques can be found in Neill (1931) and Schabacker (1930). The use of moving averages was discussed by Gartley (1930). Further examples of the important early studies of these techniques have been carefully collected in Coslow [and Schultz] (1966). The early use and popularity of these methods reduces the possibility that data-snooping biases are driving our results since we have at least 60 years of "fresh" data.

Accordingly, the aim of this study is to investigate the predictability of the two technical rules in the Taiwan stock market, through which logical inference can be made about its market efficiency. That is, if our empirical tests indicate their predictability, then the stock market of Taiwan is not weak-form efficient. In addition, to gauge the effect of the financial reform and liberalization measures implemented since the early 1990s on the two technical rules, we divide the full sample period of 1975-2007 into three 11-year-long subperiods: 1975-1985, 1986-1996, and 1997-2007. In Section 3, we will point out that, in Taiwan, basically no financial reform took place in the first subperiod, part of the financial reform was implemented midway in the second subperiod, and the financial reform was completed in the third subperiod. By this division of the full sample period, we can gauge if the two technical rules have different degrees of predictability in the three subperiods.

The rest of the paper proceeds as follows: Section 2 reviews the previous literature on the efficacy of technical rules that have been used in developed and developing markets. In Section 3, we give a short account of the past performance of the Taiwan stock market and its liberalization of portfolio investment by foreigners since the early 1990s. Section 4 describes how the two technical rules are implemented. In Section 5, we present summary statistics of the data and describe the hypothesis tests used. Section 6 presents and discusses the results. Section 7 concludes and points out some implication of our results.

LITERATURE REVIEW

Since technical analysis was first proposed by Charles Dow in the early 1900s, there have been numerous types of technical rules for practical use. Some popular types of technical rules investigated by financial academics, to name just a few, include channels (e.g., Donchian, 1960; Irwin and Uhrig, 1984), filters (e.g., Alexander, 1961 and 1964; Fama and Blume, 1966; Sweeney, 1988), momentum oscillators (e.g., Smidt, 1965), moving averages (e.g., Cootner, 1962; Van and Parker, 1967; James, 1968), relative strength (e.g., Levy, 1967a, 1967b; Jensen and Benington, 1970). In the following, we focus on previous empirical studies which investigate the efficacy of technical rules that have been used in developed and developing markets.

Early empirical studies do not lend support to technical rules. Using daily price data on the DJIA from 1897 to 1929 and the S&P Industrial Index from 1929 to 1959, Alexander (1964) conducts extensive tests of filter rules and concludes that their performance, in terms of profitability, is no better than a simple buy-and-hold (BH) strategy when transaction costs are considered. Fama and Blume (1966) re-investigate the profitability of Alexander's filter rules using daily data of 30 individual DJIA stocks from 1956 to 1962 and conclude that the filter rules do not yield profits, net of transaction costs, higher than those of a BH strategy. Other studies (e.g., Van Horne and Parker, 1967, 1968; James, 1968; Jensen and Benington, 1970), using U.S. equity price data, also provide evidence that returns from moving average or relative strength rules are no greater than those from a BH strategy.

In sharp contrast, many empirical studies over the last 20 years tend to support the efficacy of technical rules. Using daily U. S. price data on individual stocks for the period 1970-1982, Sweeney (1988) reexamines some of the results from Fama and Blume (1966) and finds that the filter rules outperform a simple BH strategy even after adjusting for transaction costs and risk. Generally considered a classic empirical work on technical rules, Brock *et al.* (1992), using daily data for the DJIA from 1897 to 1986, provide strong support for the two simple technical rules, namely moving average (MA) and trading range breakout (TRB). In particular, their study shows that returns from buy signals are consistently higher than those from sell signals.

Many later studies (e.g., Bessembinder and Chan, 1995; Hudson *et al.*, 1996; Ratner and Leal, 1999; Coutts and Cheung, 2000; Gunasekarage and Power, 2001; Marshall and Cahan, 2005; Lai and Lau, 2006; Hatgioannides and Mesomeris, 2007) adopt the methodology of Brock *et al.* (1992) and employ similar technical rules to examine their efficacy in markets other than those of the United States. For example, Hudson *et al.* (1996), using daily data on the Financial Times Industrial Index from 1935 to 1994, find that the MA and TRB rules do have predictive power in terms of the UK data, but their returns are no better than a BH strategy when transaction costs are considered. Gunasekarage and Power (2001) investigate the profitability of two variants of the MA rules in four emerging South Asian markets (i.e., the Bombay Stock Exchange, the Colombo Stock Exchange, the Dhaka Stock Exchange, and the Karachi Stock Exchange) and find that the returns from these two rules are higher than a BH strategy. Lai and Lau (2006), using daily data on the market indices of nine Asian stock markets from 1988 to 2003, examine the profitability of the MA and TRB rules and again provide evidence of the efficacy of the two technical rules.

TAIWAN STOCK MARKET AND ITS QFII SYSTEM

The TAIEX was first compiled in 1966 with a base value of 100. It remained rather inactive for 20 years before breaking through the 1,000 barrier on 17 October 1986 for the first time. The Taiwan stock market really picked up steam after the 1987 stock market crash and skyrocketed for the next two years. However, it experienced a crash in 1990, declining almost 80% in less than eight months from an all-time high of 12,495.34 on 10 February 1990 to a low of 2,560.47 on 1 October 1990. Over the last 15 years, domestic political instability and tense relationship with Mainland China weighed down the market, resulting in that the TAIEX rarely surpassed the 10,000 mark. Figure 1 shows the evolution of the TAIEX from 1975 to 2007.

Over the past two decades, the SFC has implemented a series of financial reform and liberalization measures intended to make its securities markets more efficient and competitive. One major measure was setting up the Qualified Foreign Institutional Investor (QFII) system in the early 1990s to allow gradual foreign participation in its stock market. At first, QFIIs were permitted to invest directly in the local stock market only under a strict set of rules. In the ensuing years, the SFC revised the QFII system many times regarding investment quota and limitations on capital remittances. For instance, in 1996, the investment ceiling was adjusted upward to US$3 billion for QFIIs and US$50 million for foreign individual investors. As Taiwan’s securities markets became more mature, the QFII system was abolished in October 2003. Hence, foreign institutional investors and foreign individual investors are required only to apply for an investment identification for stock trading in Taiwan.

Figure 1: Taiwan Stock Exchange Weighted Index: 1975-2007

Before the 1990s, local individuals accounted for the great majority of the investor population. Since the establishment of the QFII system, trading values by foreigners have increased almost year after year. In terms of percentage, annual trading by local individuals has declined whereas that by local institutions and foreigners has increased. For example, over the last ten years, annual trading decreased from 90.70% in 1998 to 70.60% in 2007 for local individual investors, while annual trading increased from 7.60% in 1998 to 11.00% in 2007 for local institutional investors and from a mere 1.70% in 1998 to almost 18.40% in 2007 for foreign institutions and individuals. As mentioned above, increasing participation of institutional investors in the stock market could have an effect on the predictability of the trading rules.

THE TWO TECHNICAL RULES

The two technical rules used in this study are variable-length moving average (VMA) and trading range breakout (TRB). The n-day moving average (MA) on day t is

$$M_{t,n} = \frac{1}{n}\sum_{k=t-n+1}^{t} P_k = \frac{1}{n}\left[P_{t-n+1} + P_{t-n+2} + \ldots + P_{t-1} + P_t\right] \tag{1}$$

where P_k is the closing price of the TAIEX on day k.

According to the VMA rules, buy and sell signals are emitted by a short MA and a long MA. Buy (sell) signals are emitted when the short MA rises above (falls below) the long MA by a prespecified percentage band. When a signal is emitted, the VMA rules require that the position be maintained until the short MA penetrates the long MA again. A popular VMA rule is 1-100, where the short MA is one day and the long MA is 100 days. Since most local individual investors trade on short-term basis, such VMA rules as 1-20 and 1-50 are often in use. To implement, we use the following VMA rules: 1-20, 5-20, 1-50, 2-50, 1-100, and 5-100. Each rule is evaluated with bands of 0% and 1%, making a total of 12 VMA rules for the full sample period and each of the three subperiods. Here a band is used to reduce the number of times an investor would have to switch between a long position in the TAIEX and a short position in the TAIEX. For example, Brock *et al.* (1992), Bessembinder and Chan (1998), and Siegel (2002) all used a 1% band for their trading rules.

According to the TRB rules, a buy signal is emitted when the current price rises above the local maximum (the maximum price over the past certain number of days) and a sell signal is emitted when the current price falls below the local minimum (the minimum price over the past certain number of days). In notation, an *m*-day local maximum on day *t* and an *m*-day local minimum on day *t* are defined respectively as

$$L\ \max[m, t] = \max\ [P_{t-m}, P_{t-m+1},\ldots P_{t-1}] \tag{2}$$

$$L\ \min[m, t] = \min\ [P_{t-m}, P_{t-m+1},\ldots P_{t-1}] \tag{3}$$

where P_k ($k = t\text{-}m, t\text{-}m\text{+}1, \ldots, t\text{-}1$) is the closing price of the TAIEX on day *k*. That is, a buy signal is emitted if $P_t > L\max[m,t]$ and a sell signal is emitted if $P_t < L\min[m,t]$. When a buy signal is emitted, the investor takes a long position in the TAIEX the next day and maintains the position for ten days. Similarly, when a sell signal is emitted, the investor takes a short position in the TAIEX the next day and maintains the position for ten days. In either case, when the ten days are over, the investor starts again waiting for a buy or sell signal. To implement, we use local maximums and minimums over the preceding 20, 50, and 100 days. Again, each rule is evaluated with bands of 0% and 1%, making a total of six TRB rules for the full sample period and each of the three subperiods.

SUMMARY STATISTICS AND HYPOTHESIS TESTS

The data used are the daily closing prices of the TAIEX from the first trading day in 1975 to the last trading day in 2007–a total of 9175 observations. They were drawn from the PACAP database and the database of Taiwan Economic Journal. In addition to those for the full sample period (1975-2007), results are also presented for the three 11-year-long subperiods: 1975-1985, 1986-1996, and 1997-2007. The Taiwan stock market was characterized by low trading activities over 1975-1985 but by high trading activities over 1986-1996 and 1997-2007. Note that the second and third subperiods cover the time span when the SFC implemented a series of financial reform and liberalization measures aimed at upgrading market efficiency and competitiveness.

Table 1 contains summary statistics for the full sample period and the three subperiods for mean 1-day and 10-day returns on the TAIEX. Returns are computed as log differences of the TAIEX level. That is,

$$R_{t+j} = \log(P_{t+j}) - \log(P_t) \tag{4}$$

where P_t and P_{t+j} ($j = 1, 10$) are the closing prices of the TAIEX on day *t* and day $t+j$, and R_{t+j} is the return from day *t* to day $t+j$. Table 1 shows that, in absolute value, the first-order autocorrelations for one-day returns over 1975-1985 and 1986-1996 are generally larger than

Table 1
Summary Statistics for 1-day and 10-day Returns

	1975-2007	*1975-1985*	*1986-1996*	*1997-2007*
Number of observations	9175	3198	3150	2827
No. of trading days a year	278	291	286	257
Mean 1-day return	0.00041	0.00046	0.00067	0.00008
1-day standard deviation	0.01619	0.01211	0.02000	0.01545
$\delta_1(1)$	0.09721	0.06434	0.13432	0.05738
$\delta_1(2)$	0.01132	-0.00835	0.01437	0.00834
$\delta_1(3)$	0.09616	0.10341	0.11343	0.05932
$\delta_1(4)$	0.01543	0.05404	0.03081	-0.04215
$\delta_1(5)$	0.00232	0.01927	0.00442	-0.01232
Mean 10-day return	0.00410	0.00452	0.00669	0.00084
10-day standard deviation	0.05948	0.04305	0.07876	0.05055
$\delta_{10}(1)$	0.15312	0.15841	0.15023	0.02943
$\delta_{10}(2)$	0.02537	0.09771	0.05628	0.01648
$\delta_{10}(3)$	0.00681	-0.03243	-0.00786	0.01826
$\delta_{10}(4)$	-0.00864	-0.01569	0.00874	0.08751
$\delta_{10}(5)$	0.02112	0.03346	-0.03217	-0.01872

$\delta_j(i)$ is the estimated j-day autocorrelation at lag i for each series, where $i = 1, 2, 3, 4, 5$ and $j = 1, 10$.

those over 1997-2007, which suggests that the Taiwan stock market over the first two subperiods was relatively more at odds with the notion of efficient markets than over the third subperiod.

A one-sided hypothesis test is used. For buys, the hypothesis is H_{01} : μb(j) = μ(j) and the alternative is H_{a1}: μb(j) > μ(j), where $\mu_b(j)$ is the mean j-day return for buys and $\mu(j)$ is the unconditional mean j-day return. The test statistic for buys is

$$Z_b(j) = \frac{\overline{r_b}(j) - \mu(j)}{\sigma(j)\sqrt{\dfrac{1}{n_b(j)}}} \tag{5}$$

where $\overline{r_b}(j)$ is the sample mean j-day return for buys, $n_b(j)$ is the number of buy signals, and $\sigma(j)$ is the j-day standard deviation. For sells, the hypothesis is H_{02}: $\mu_s(j) = \mu(j)$ and the alternative is H_{a2}: $\mu_s(j) > \mu(j)$, where $\mu_s(j)$ is the mean j-day return for sells. The test statistic for sells is

$$Z_s(j) = \frac{\overline{r_s}(j) - \mu(j)}{\sigma(j)\sqrt{\dfrac{1}{n_s(j)}}} \tag{6}$$

where $\overline{r_s}(j)$ is the sample mean j-day return for sells and $n_s(j)$ is the number of sell signals. For buys-sells, the hypothesis is H_{03}: $\mu_b(j) = \mu_s(j)$ and the alternative is H_{a3}: $\mu_b(j) > \mu_s(j)$. The test statistic for buys-sells is

$$Z_{b-s}(j) = \frac{\bar{r}_b(j) - \bar{r}_s(j)}{\sigma(j)\sqrt{\frac{1}{n_b(j)} + \frac{1}{n_s(j)}}} \quad (7)$$

Given large sample size, all the three test statistics are distributed as $N(0, 1)$ if their null hypotheses are true. Accordingly, given the critical normal value z_α, if $Z_b(j) > z_\alpha$, we reject H_{01} and conclude that the mean *j*-day return for buys is greater than the unconditional mean *j*-day return at α significance level. Similarly, if $Z_s(j) > z_\alpha$, we reject H_{02} and conclude that the mean *j*-day return for sells is greater than the unconditional mean *j*-day return at α significance level. In addition, if $Z_{b-s}(j) > z_\alpha$, we reject H_{03} and conclude that the mean *j*-day return for buys is larger than the mean *j*-day return for sells at α significance level. For the three tests, we set the significance level α at 1% and 5%.

RESULTS AND DISCUSSION

As mentioned in Section 1, the EMH (Fama, 1970) says that an efficient market is one in which security prices fully reflect all available information. This is a very strong hypothesis because it does not take information and trading costs into consideration. Its advantage, according to Fama (1991), is that "it is a clean benchmark that allows me to sidestep the messy problem of deciding what are reasonable information and trading costs. I can focus instead on the more interesting task of laying out the evidence on the adjustment of prices to various kinds of information." Hence, in this study, we do not take transaction costs into consideration.

Accordingly, if the Taiwan stock market is weak-form efficient, then the two technical rules should not be able to generate abnormal returns. Specifically, the mean returns for buy signals (or sell signals) should not differ notably from the corresponding unconditional mean returns. In addition, the mean returns for buy signals should not differ significantly from the mean returns for sell signals. In the following, we will first look at the results for the VMA rules and then those for the TRB rules.

VMA Trading Rules

Table 2 shows the results for the VMA rules for 1975-2007. For each of the 12 rules, there are more buy signals than sell signals, which suggests that the market tended to drift upward. The mean 1-day returns for buys are all positive with an average 1-day return of 0.00115, which is considerably larger than the unconditional mean 1-day return of 0.00041 (see Table 1). Using a one-tailed test, all the 12 rules reject that the mean 1-day returns for buys equal the unconditional mean 1-day return at either 5% or 1% level. Hence, we conclude that the buy signals generated by the 12 rules have obvious predictive power for the full sample period.

In contrast, the mean 1-day returns for sells, although all positive, have an average 1-day return of 0.00043, which is almost equal to the unconditional mean 1-day return of 0.00041. Using a one-tailed test, we do not reject H_{02} that the mean 1-day returns for sells equal the unconditional mean 1-day return at either 5% or 1% level. As a result, the Buy-Sell column in Table 2 shows that all the 12 rules reject H_{03} that the mean 1-day returns for buys equal the mean 1-day returns for sells at either 5% or 1% level. Hence, we conclude that the buy signals have more predictive power than the sell signals for the full sample period.

Table 2
Results for Variable-length Moving Average Rules: 1975-2007

Rule	*n(Buy)*	*n(Sell)*	*Buy*	*Sell*	*Buy-Sell*
(1, 20, 0%)	4928	4226	0.00125	0.00062	0.00063
			(3.62534)**	(0.82725)	(1.85627)*
(5, 20, 0%)	4944	4210	0.00097	0.00030	0.00067
			(2.41502)**	(-0.45693)	(1.97359)*
(1, 50, 0%)	4834	4290	0.00131	0.00069	0.00064
			(3.84829)**	(1.11672)	(1.82595)*
(5, 50, 0%)	4861	4263	0.00112	0.00046	0.00065
			(3.04071)**	(0.18553)	(1.94303)*
(1, 100, 0%)	4967	4107	0.00091	0.00028	0.00062
			(2.15941)*	(-0.53049)	(1.84526)*
(5, 100, 0%)	4950	4124	0.00092	0.00030	0.00062
			(2.19918)*	(-0.45224)	(1.81661)*
(1, 20, 1%)	3924	3253	0.00157	0.00071	0.00086
			(4.47331)**	(1.04289)	(2.24048)*
(5, 20, 1%)	3696	3005	0.00121	0.00020	0.00101
			(2.98941)**	(-0.72467)	(2.54008)**
(1, 50, 1%)	4366	3706	0.00142	0.00062	0.00080
			(4.10626)**	(0.77469)	(2.21259)*
(5, 50, 1%)	4311	3706	0.00126	0.00038	0.00088
			(3.43136)**	(-0.12786)	(2.42675)**
(1, 100, 1%)	4629	3753	0.00096	0.00037	0.00059
			(2.29479)*	(-0.16651)	(1.65927)*
(5, 100, 1%)	4620	3758	0.00089	0.00027	0.00062
			(1.99864)*	(-0.54532)	(1.74352)*
Average			0.00115	0.00043	0.00072

Rules are identified as (short, long, band), where short and long are the lengths of short and long moving averages respectively, and band is the percentage difference required to generate a buy or sell signal. *n*(Buy) and *n*(Sell) are the numbers of buy and sell signals emitted over 1975-2007. Figures in parentheses are standard *z* values testing the difference of mean buy 1-day return (or mean sell 1-day return) from unconditional mean 1-day return, and that of mean buy-sell 1-day return from 0. Figures with * (**) are significant at 5% (1%) level for a one-tailed test.

Tables 3 and 4 show the results for 1975-1985 and 1986-1996. In general, the results for these two subperiods are quite similar. Specifically, the mean 1-day returns for buys are all larger than those for sells, with an average 1-day return of 0.00104 for buy signals and only 0.00020 for sell signals over 1975-1985 and 0.00185 for buy signals and 0.00079 for sell signals over 1986-1996. For 1975-1985, seven out of the 12 rules reject H_{01} that the mean 1-day returns for buys equal the unconditional mean 1-day return of 0.00046 at either 5% or 1% level using a one-tailed test. For 1986-1996, all the 12 rules reject H_{01} that the mean 1-day returns for buys equal the unconditional mean 1-day return of 0.00067 at 1% level using a one-tailed test.

Table 3
Results for Variable-length Moving Average Rules: 1975-1985

Rule	*n(Buy)*	*n(Sell)*	*Buy*	*Sell*	*Buy-Sell*
(1, 20, 0%)	1611	1566	0.00122	0.00048	0.00074
			(2.67052)**	(0.21560)	(1.72139)*
(5, 20, 0%)	1593	1584	0.00089	0.00013	0.00076
			(1.56829)	(-0.93306)	(1.76808)*
(1, 50, 0%)	1573	1574	0.00103	0.00030	0.00073
			(2.01678)*	(-0.37335)	(1.69026)*
(5, 50, 0%)	1589	1558	0.00100	0.00029	0.00071
			(1.92829)*	(-0.40403)	(1.64387)
(1, 100, 0%)	1559	1538	0.00076	0.00011	0.00065
			(1.12775)	(-0.98416)	(1.49299)
(5, 100, 0%)	1556	1541	0.00074	0.00009	0.00065
			(1.06154)	(-1.04993)	(1.49301)
(1, 20, 1%)	1195	1136	0.00163	0.00043	0.00120
			(3.47000)**	(0.04452)	(2.39054)**
(5, 20, 1%)	1131	1052	0.00128	-0.00022	0.00150
			(2.40415)**	(-1.69750)*	(2.89079)**
(1, 50, 1%)	1391	1329	0.00121	0.00029	0.00092
			(2.45069)**	(-0.37316)	(1.97989)*
(5, 50, 1%)	1366	1323	0.00116	0.00020	0.00096
			(2.27602)*	(-0.64255)	(2.05444)*
(1, 100, 1%)	1419	1405	0.00080	0.00016	0.00064
			(1.20030)	(-0.78593)	(1.40375)
(5, 100, 1%)	1425	1408	0.00074	0.00016	0.00058
			(1.01587)	(-0.78677)	(1.27417)
Average			0.00104	0.00020	0.00084

Rules are identified as (short, long, band), where short and long are the lengths of short and long moving averages respectively, and band is the percentage difference required to generate a buy or sell signal. *n*(Buy) and *n*(Sell) are the numbers of buy and sell signals emitted over 1975-1985. Figures in parentheses are standard *z* values testing the difference of mean buy 1-day return (or mean sell 1-day return) from unconditional mean 1-day return, and that of mean buy-sell 1-day return from 0. Figures with * (**) are significant at 5% (1%) level for a one-tailed test.

In Table 5, the results for 1997-2007 are in sharp contrast to those for 1975-1985 and 1986-1996. The mean 1-day returns for buys are not much different from those for sells, with an average 1-day return of 0.00037 for buy signals and 0.00033 for sell signals. Using a one-tailed test, none of the 12 trading rules reject H_{01} (or H_{02}) that the mean 1-day returns for buys (or sells) equal the unconditional mean 1-day return of 0.00008 at either 5% or 1% significance level.

TRB Trading Rules

Table 6 reports the results for the TRB rules for 1975-2007. Again, for each of the six trading rules, the mean 10-day returns for buys are all positive with an average 10-day return of 0.0177, which is considerably larger than the unconditional mean 10-day return of 0.0041

Table 4
Results for Variable-length Moving Average Rules: 1986-1996

Rule	*n(Buy)*	*n(Sell)*	*Buy*	*Sell*	*Buy-Sell*
(1, 20, 0%)	1764	1365	0.00219	0.00131	0.00088
			(4.60786)**	(2.04494)*	(1.50800)
(5, 20, 0%)	1785	1344	0.00174	0.00077	0.00097
			(3.46074)**	(0.80623)	(1.65918)*
(1, 50, 0%)	1715	1384	0.00202	0.00106	0.00096
			(4.10851)**	(1.48459)	(1.64122)
(5, 50, 0%)	1728	1371	0.00174	0.00074	0.00100
			(3.40504)**	(0.74566)	(1.70800)*
(1, 100, 0%)	1777	1272	0.00152	0.00053	0.00099
			(2.88009)**	(0.25557)	(1.66514)*
(5, 100, 0%)	1752	1297	0.00148	0.00043	0.00105
			(2.75633)**	(0.03560)	(1.77074)*
(1, 20, 1%)	1470	1091	0.00245	0.00134	0.00111
			(4.82218)**	(1.88943)*	(1.71592)*
(5, 20, 1%)	1402	1018	0.00207	0.00073	0.00134
			(3.83037)**	(0.62283)	(2.01026)*
(1, 50, 1%)	1573	1214	0.00214	0.00102	0.00112
			(4.22875)**	(1.30433)	(1.81105)*
(5, 50, 1%)	1548	1218	0.00194	0.00065	0.00129
			(3.70891)**	(0.50879)	(2.08056)*
(1, 100, 1%)	1683	1191	0.00156	0.00067	0.00089
			(2.90425)**	(0.54576)	(1.45195)
(5, 100, 1%)	1678	1195	0.00139	0.00026	0.00113
			(2.46975)**	(-0.32886)	(1.84415)*
Average			0.00185	0.00079	0.00106

Rules are identified as (short, long, band), where short and long are the lengths of short and long moving averages respectively, and band is the percentage difference required to generate a buy or sell signal. *n*(Buy) and *n*(Sell) are the numbers of buy and sell signals emitted over 1986-1996. Figures in parentheses are standard *z* values testing the difference of mean buy 1-day return (or mean sell 1-day return) from unconditional mean 1-day return, and that of mean buy-sell 1-day return from 0. Figures with * (**) are significant at 5% (1%) level for a one-tailed test.

(see Table 1). Using a one-tailed test, all the six rules reject H_{01} that the mean 10-day returns for buys equal the unconditional mean 10-day return of 0.0041 at 1% level. In contrast, the mean 10-day returns for sells have an average 10-day return of only 0.00167. Naturally, the Buy-Sell column in Table 6 shows that all the six rules reject H_{03} that the mean 10-day returns for buys equal the mean 10-day returns for sells at either 5% or 1% significance level. Hence, we conclude that buy signals possess more predictive power than sell signals for 1975-2007.

Tables 7 and 8 report the results for 1975-1985 and 1986-1996. Again, the results for these two subperiods are similar. Specifically, the mean 10-day returns for buys are all larger than those for sells. Using a one-tailed test, four out of the six rules for 1975-1985 reject H_{01} that the mean 10-day returns for buys equal the unconditional mean 10-day return of 0.00452 at either 5% or 1% significance level, and all the six rules for 1986-1996 reject H_{01} that the mean 10-day returns for buys equal the unconditional mean 10-day return of 0.00669 at either 5% or 1% significance level.

In Table 9, the results for 1997-2007 are again noticeably different from those for 1975-1985 and 1986-1996. The average 10-day return is 0.00243 for buys and –0.00198 for sells. Based on a one-tailed test, none of the six rules reject H_{01} (or H_{02}) that the mean 10-day returns for buys (or sells) equal the unconditional mean 10-day return of 0.00084 at either 5% or 1% significance level.

Table 5
Results for Variable-length Moving Average Rules: 1997-2007

Rule	*n(Buy)*	*n(Sell)*	*Buy*	*Sell*	*Buy-Sell*
(1, 20, 0%)	1514	1292	0.00020	0.00010	0.00010
			(-0.51438)	(-0.69722)	(0.16310)
(5, 20, 0%)	1524	1282	0.00013	0.00002	0.00011
			(-0.68488)	(-0.87146)	(0.17930)
(1, 50, 0%)	1444	1332	0.00066	0.00069	-0.00003
			(0.57746)	(0.62225)	(-0.04878)
(5, 50, 0%)	1442	1334	0.00037	0.00038	-0.00001
			(-0.10321)	(-0.07671)	(-0.01626)
(1, 100, 0%)	1439	1287	0.00028	0.00026	0.00002
			(-0.31401)	(-0.34128)	(0.03220)
(5, 100, 0%)	1449	1277	0.00043	0.00044	-0.00001
			(0.03762)	(0.05740)	(-0.01609)
(1, 20, 1%)	1226	1026	0.00045	0.00034	0.00011
			(0.07787)	(-0.14642)	(0.16060)
(5, 20, 1%)	1135	935	0.00012	0.00009	0.00003
			(-0.61186)	(-0.61201)	(0.04196)
(1, 50, 1%)	1302	1163	0.00068	0.00059	0.00009
			(0.59292)	(0.37077)	(0.13780)
(5, 50, 1%)	1295	1165	0.00042	0.00030	0.00012
			(0.01334)	(-0.24037)	(0.18358)
(1, 100, 1%)	1340	1153	0.00037	0.00032	0.00005
			(-0.09950)	(-0.19717)	(0.07689)
(5, 100, 1%)	1329	1149	0.00038	0.00044	-0.00006
			(-0.07657)	(0.05444)	(-0.09201)
Average			0.00037	0.00033	0.00004

Rules are identified as (short, long, band), where short and long are the lengths of short and long moving averages respectively, and band is the percentage difference required to generate a buy or sell signal. *n*(Buy) and *n*(Sell) are the numbers of buy and sell signals emitted over 1997-2007. Figures in parentheses are standard *z* values testing the difference of mean buy 1-day return (or mean sell 1-day return) from unconditional mean 1-day return, and that of mean buy-sell 1-day return from 0.

Table 6
Results for Trading range Breakout Rules: 1975-2007

Rule	*n(Buy)*	*n(Sell)*	*Buy*	*Sell*	*Buy-Sell*
(10, 20, 0%)	320	258	0.01389	0.00385	0.01004
			(2.94513)**	(-0.06670)	(2.01729)*
(10, 50, 0%)	244	175	0.01564	-0.00013	0.01577
			(3.03129)**	(-0.94008)	(2.67641)**
(10, 100, 0%)	186	106	0.01724	0.00274	0.01450
			(3.01346)**	(-0.23488)	(2.00309)*
(10, 20, 1%)	218	192	0.01717	0.00474	0.01243
			(3.24502)**	(0.14979)	(2.11141)*
(10, 50, 1%)	150	134	0.02118	-0.00045	0.02163
			(3.51742)**	(-0.88490)	(3.05921)**
(10, 100, 1%)	117	78	0.02105	-0.00074	0.02178
			(3.08286)**	(-0.71819)	(2.50608)**
Average			0.01770	0.00167	0.01603

Rules are identified as (day, signal, band), where day is the number of days for the investment horizon and signal is the number of past days used to generate a maximum or minimum price, and band is the percentage difference needed to generate a signal. *n*(Buy) and *n*(Sell) are the numbers of buy and sell signals emitted over 1975-2007. Figures in parentheses are standard *z* values testing the difference of mean buy 10-day return (or mean sell 10-day return) from unconditional mean 10-day return, and that of mean buy-sell 10-day return from 0. Figures with * (**) are significant at 5% (1%) level for a one-tailed test.

Table 7
Results for Trading Range Breakout Rules: 1975-1985

Rule	*n(Buy)*	*n(Sell)*	*Buy*	*Sell*	*Buy-Sell*
(10, 20, 0%)	104	96	0.01073	-0.00110	0.01182
			(1.47094)	(-1.27940)	(1.94169)*
(10, 50, 0%)	74	63	0.01690	-0.00108	0.01798
			(2.47377)**	(-1.03274)	(2.43653)**
(10, 100, 0%)	58	41	0.01211	-0.00229	0.01440
			(1.34263)	(-1.01312)	(1.63949)
(10, 20, 1%)	66	64	0.01754	-0.00261	0.02015
			(2.45701)**	(-1.32525)	(2.66822)**
(10, 50, 1%)	44	44	0.01693	-0.00755	0.02448
			(1.91214)*	(-1.86006)*	(2.66735)**
(10, 100, 1%)	34	25	0.01951	-0.01164	0.03115
			(2.03034)*	(-1.87713)*	(2.74662)**
Average			0.01562	-0.00438	0.02000

Rules are identified as (day, signal, band), where day is the number of days for the investment horizon and signal is the number of past days used to generate a maximum or minimum price, and band is the percentage difference needed to generate a signal. *n*(Buy) and *n*(Sell) are the numbers of buy and sell signals emitted over 1975-1985. Figures in parentheses are standard *z* values testing the difference of mean buy 10-day return (or mean sell 10-day return) from unconditional mean 10-day return, and that of mean buy-sell 10-day return from 0. Figures with * (**) are significant at 5% (1%) level for a one-tailed test.

Table 8
Results for Trading Range Breakout Rules: 1986-1996

Rule	*n(Buy)*	*n(Sell)*	*Buy*	*Sell*	*Buy-Sell*
(10, 20, 0%)	114	77	0.02467	0.01410	0.01057
			(2.43768)**	(0.82572)	(0.90984)
(10, 50, 0%)	86	52	0.02557	0.00889	0.01668
			(2.22323)*	(0.20153)	(1.20564)
(10, 100, 0%)	65	30	0.02876	0.01491	0.01385
			(2.25938)*	(0.57174)	(0.79674)
(10, 20, 1%)	85	62	0.02702	0.01677	0.01025
			(2.38001)**	(1.00788)	(0.77926)
(10, 50, 1%)	59	44	0.03239	0.00905	0.02334
			(2.50661)**	(0.19885)	(1.48780)
(10, 100, 1%)	48	25	0.03170	0.01086	0.02084
			(2.20020)*	(0.26480)	(1.07285)
Average			0.02835	0.01243	0.01592

Rules are identified as (day, signal, band), where day is the number of days for the investment horizon and signal is the number of past days used to generate a maximum or minimum price, and band is the percentage difference needed to generate a signal. *n*(Buy) and *n*(Sell) are the numbers of buy and sell signals emitted over 1986-1996. Figures in parentheses are standard *z* values testing the difference of mean buy 10-day return (or mean sell 10-day return) from unconditional mean 10-day return, and that of mean buy-sell 10-day return from 0. Figures with * (**) are significant at 5% (1%) level for a one-tailed test.

Table 9
Results for Trading Range Breakout Rules: 1997-2007

Rule	*n(Buy)*	*n(Sell)*	*Buy*	*Sell*	*Buy-Sell*
(10, 20, 0%)	99	84	0.00234	0.00039	0.00195
			(0.29525)	(-0.08159)	(0.26004)
(10, 50, 0%)	76	60	0.00183	-0.00695	0.00878
			(0.17073)	(-1.19369)	(1.00574)
(10, 100, 0%)	51	35	0.00295	-0.00181	0.00476
			(0.29809)	(-0.31014)	(0.42900)
(10, 20, 1%)	66	66	0.00292	0.00056	0.00236
			(0.33428)	(-0.04500)	(0.26819)
(10, 50, 1%)	43	46	0.00168	-0.00274	0.00442
			(0.10897)	(-0.48033)	(0.41221)
(10, 100, 1%)	29	28	0.00284	-0.00135	0.00419
			(0.21306)	(-0.22925)	(0.31285)
Average			0.00243	-0.00198	0.00441

Rules are identified as (day, signal, band), where day is the number of days for the investment horizon and signal is the number of past days used to generate a maximum or minimum price, and band is the percentage difference needed to generate a signal. *n*(Buy) and *n*(Sell) are the numbers of buy and sell signals emitted over 1997-2007. Figures in parentheses are standard *z* values testing the difference of mean buy 10-day return (or mean sell 10-day return) from unconditional mean 10-day return, and that of mean buy-sell 10-day return from 0.

CONCLUSION AND IMPLICATION

Sharpe *et al.* (1999) assert that, in an efficient market, "publicly known investment strategies cannot be expected to generate abnormal returns." In this study, we employ two popular technical trading rules to evaluate their predictability in the Taiwan stock market. Our results show that, for the two rules, buy signals consistently generate much higher returns than sell signals. In addition, the two rules display considerable predictive power over 1975-1985 and 1986-1996 but become less effective over 1997-2007. These results suggest that the financial reform and liberalization measures (particularly the QFII system) implemented by the SFC since the early 1990s have contributed, to a certain degree, to the improved efficiency of the Taiwan stock market. (We cannot claim, based on our findings, that the reform measures implemented are solely responsible for improving the efficiency of the Taiwan stock market. But they are certainly one of the major forces that have led to its improved efficiency.)

Like Taiwan in the 1990s, China has tried to upgrade the efficiency of its securities markets over the last decade. Also, like Taiwan in the past, China has been very cautious toward foreign participation in its financial markets and, to prevent uncontrolled market volatility, imposed a series of restrictions on portfolio investment by foreigners. Interestingly, in many areas, China has modeled its financial market systems after those of Taiwan. The QFII system is a case in point. On 1 December 2002, China passed its QFII Act which allows qualified foreign institutional investors to invest in Chinese equities. Hence, the results of this study have an important implication for the development of China's securities markets. That is, gradual relaxation of foreign portfolio investment restrictions should help to improve the efficiency of its securities markets.

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References

Alexander, S. S. (1961), "Price Movements in Speculative Markets: Trends or Random Walks", *Industrial Management Review*, 2: 7-26.

Alexander, S. S. (1964), "Price Movements in Speculative Markets: Trends or Random Walks, Number 2", *Industrial Management Review*, 5: 25-46.

Barber, B. M., Lee, Y. T., Liu, Y. J. and Odean, T. (2006), "Just How Much do Individual Investors Lose by Trading?" Working paper.

Bessembinder, H. and Chan, K. (1995), "The Profitability of Technical Trading Rules in the Asian Stock Markets", *Pacific-Basin Finance Journal*, 3: 257-284.

Bessembinder, H. and Chan, K. (1998), "Market Efficiency and the Returns to Technical Analysis", *Financial Management*, 27(2): 5-17.

Black, F. (1986), "Noise", *Journal of Finance*, 41: 529-543.

Blume, L., Easley, D. and O'Hara, M. (1994), "Market Statistics and Technical Analysis: the Role of Volume", *Journal of Finance*, 49: 153-181.

Brock, W., Lakonishok, J. and LeBaron, B. (1992), "Simple Technical Trading Rules and the Stochastic Properties of Stock Returns", *Journal of Finance*, 47: 1731-1764.

Cootner, P. H. (1962), "Stock Prices: Random vs. Systematic Changes", *Industrial Management Review*, 3: 24-45.

Coslow, S. and Schultz, H. D. (1966), *A Treasury of Wall Street Wisdom*, Investors Press Inc., Pallisades Park, N.Y.

Coutts, J. A. and Cheung, K. C. (2000), "Trading Rules and Stock Returns: Some Preliminary Short Run Evidence from the Hang Seng 1985-1997", *Applied Financial Economics*, 10: 579-586.

De Bondt, W. F. M. and Thaler, R. H. (1985), "Does the Stock Market Overreact?" *Journal of Finance*, 40: 793-805.

Donchian, R. D. (1960), "High Finance in Copper", *Financial Analysts Journal*, November-December: 133-142.

Fama, E. F. (1965), "The Behavior of Stock Prices", *Journal of Business*, 37(1): 34-105.

Fama, E. F. (1970), "Efficient Capital Markets: A Review of Theory and Empirical Work", *Journal of Finance*, 25: 383-417.

Fama, E. F. (1991), "Efficient Capital Markets: II", *Journal of Finance*, 46(5): 1575-1617.

Fama, E. F. and Blume, M. (1966), "Filter Rules and Stock Market Trading Profits", *Journal of Business*, Special Supplement (January): 226-241.

Gencay, R. (1998), "The Predictability of Security Returns with Simple Technical Trading Rules", *Journal of Empirical Finance*, 5: 347-359.

Gartley, H. M. (1930), *Profits in the Stock Market*, H. M. Gartley Inc., New York, N.Y.

Gunasekarage, A. and Power, D. M. (2001), "The Profitability of Moving Average Trading Rules in South Asian Stock Markets", *Emerging Markets Review*, 2: 17-33.

Hatgioannides, J. and Mesomeris, S. (2007), "On the Returns Generating Process and the Profitability of Trading Rules in Emerging Capital Markets", *Journal of International Money & Finance*, 26: 948-973.

Hudson, R., Dempsey, M. and Keasey, K. (1996), "A Note on the Weak Form Efficiency of Capital Markets: the Application of Simple Technical Trading Rules to UK Stock Prices–1935 to 1994", *Journal of Banking & Finance*, 20: 1121-1132.

Irwin, S. H. and Uhrig, J. W. (1984), "Do Technical Analysis have Holes in their Shoes?" *Review of Research in Futures Markets*, 3: 264-277.

James, F. E. (1968), "Monthly Moving Averages–An Effective Investment Tool?" *Journal of Financial and Quantitative Analysis*, September: 315-326.

Jensen, M. (1978), "Some Anomalous Evidence regarding Market Efficiency", *Journal of Financial Economics*, 6: 95-101.

Jensen, M. and Benington, G. (1970), "Random Walks and Technical Theories: Some Additional Evidence", *Journal of Finance*, 25: 469-482.

Lai, M. M. and Lau, S. H. (2006), "The Profitability of the Simple Moving Averages and Trading Range Breakout in the Asian Stock Markets", *Journal of Asian Economics*, 17: 144-170.

Lehmann, B. N. (1990), "Fads, Martingales, and Market Efficiency", *Quarterly Journal of Economics*, 105: 1-28.

Levy, R. A. (1967a), "Random Walks: Reality or Myth", *Financial Analysts Journal*, 23: 69-77.

Levy, R. A. (1967b), "Relative Strength as a Criterion for Investment Selection", *Journal of Finance*, 22: 595-610.

Lo, A. W. and MacKinlay, C. A. (1990), "When are Contrarian Profits due to Stock Market Overreaction?" *Review of Financial Studies*, 3: 175-206.

Marshall, B. R. and Cahan, R. H. (2005), "Is Technical Analysis Profitable on a Stock Market which has Characteristics that Suggest It may be Inefficient?" *Research in International Business and Finance*, 19: 384-398.

Metghalchi, M., Chang, Y. H. and Marcucci, J. (2008), "Is the Swedish Stock Market Efficient? Evidence from Some Simple Technical Rules", *International Review of Financial Analysis*, 17: 475-490.

Neill, H. B. (1931), *Tape Reading and Market Tactics*, Forbes Publishing, New York, N.Y.

Para, T. P. (1995), "Yes, You can beat the Market", *Fortune*,131: 68-70.

Poterba, J. M. and Summers, L. H. (1988), "Mean Reversion in Stock Prices: Evidence and Implications", *Journal of Financial Economics*, 22: 27-59.

Ratner, M. and Leal, R. P. C. (1999), "Tests of Technical Trading Strategies in the Emerging Equity Markets of Latin America and Asia", *Journal of Banking and Finance*, 23: 1887-1905.

Samuelson, P. A. (1965), "Proof that Properly Anticipated Prices Fluctuate Randomly", *Industrial Management Review*, 6: 41-49.

Schabacker, R. (1930), *Stock Market Theory and Practice*, Forbes Publishing, New York, N.Y.

Sharpe, W. F., Alexander, G. J. and Bailey, J. V. (1999), *Investments*, sixth edition, Prentice-Hall International, Inc., New Jersey.

Siegel, J. J. (2002), *Stocks for the Long Run*, third edition, McGraw-Hill, New York.

Smidt, S. (1965), "A Test of Serial Independence of Price Changes in Soybean Futures", *Food Research Institute Studies*, 5: 117-136.

Sweeney, R. (1988), "Some New Filter Rule Tests: Methods and Results", *Journal of Financial and Quantitative Analysis*, 23: 285-300.

Van Horne, J. C. and Parker, G. G. (1967), "The Random Walk Theory: An Empirical Test", *Financial Analysts Journal*, November-December: 87-92.

Van Horne, J. C. and Parker, G. G. (1968), "Technical Trading Rules: A Comment", *Financial Analysts Journal*, 24: 128-132.

Wong, W. K., Manzur, M. and Chew, B. K. (2003), "How Rewarding is Technical Analysis? Evidence from Singapore Stock Market", *Applied Financial Economics*, 13: 543-551.

Wyckoff, R. (1910), *Studies in Tape Reading*, Fraser Publishing Co., Burlington, V.T.