The Review of Finance and Banking
Volume 01, Issue 1, Year 2009, Pages 007–013
S print ISSN 2067-2713 online ISSN 2067-3825

ADAPTIVE MARKETS HYPOTHESIS: EVIDENCE FROM ASIA-PACIFIC FINANCIAL MARKETS

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Abstract. In this paper we investigate the profitability of the moving average strategy on six Asian capital markets considering the episodic character of linear and/or nonlinear dependencies, the period under study being 1997-2008. For each market, the most profitable strategy from 15000 alternatives is selected. The main conclusion is that profitability of moving average strategies is not constant in time; it is episodic showing when sub-periods of linear and non-linear correlation appear. Thus, one can thus say that the degree of market efficiency varies through time in a cyclical fashion over time and these statistical features are in line with those postulated by Adaptive Markets Hypothesis (AMH) of Lo (2004, 2005).

1. Introduction

Numerous recent studies have used the Hinich–Patterson windowed-test procedure (1995) to research the temporal persistence of linear and especially nonlinear dependencies on the emergent stock markets. Thus, Lim and Hinich (2005) in Asian Stock Markets, Bonilla et al. (2006) in Latin American Stock Markets and Todea and Zoicas-Ienciu (2008) in Central and Eastern Europe stock markets are emphasizing the existence of different stock price behaviors, namely long random walk sub periods alternating with short ones characterized by strong linear and/or nonlinear correlations. All these studies suggest that these serial dependencies have an episodic nature being also the main cause for the low performance of the forecasting models.

In this context, Lim, Brooks and Hinich (2006) computed the bi-correlation statistics of Hinich (1996) in fixed-length moving sub-sample windows and found that nonlinear predictability for Asian emergent markets follows an evolutionary time path. The results of this test of evolving efficiencies are in line with those postulated by Adaptive Markets Hypothesis (AMH) of Lo (2004, 2005) according to which the profit opportunities do exist from time to time. In another study Lim, Brooks and Hinich (2007), relying on the same test, found that the cross-country differences in nonlinear departure from market efficiency can be explained by market size and trading activity, while the transient burst of nonlinear periods in each market can be attributed to the occurrence of economic and political events. Lim (2007) compute the bi-correlation statistics in rolling sample windows and ranking market efficiency from the percentage of windows in which these statistics reject the random walk hypothesis. By a similar approach, Cajueiro and Tabak (2004) employed a rolling sample approach to compute the Hurst

Received by the editors May 11, 2009. Accepted by the editors November 23, 2009.
Keywords: episodic dependencies, bicorrelation test, technical analysis, adaptive market hypothesis.
JEL Classification: C15, G11, G14.
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This paper is in final form and no version of it will be submitted for publication elsewhere.

exponent, for testing the presence of long-term predictability in Asian equity markets. These authors rank the markets using the medians of those computed rolling Hurst exponents. The rolling bi-correlation test statistics is used by Lim Brooks and Kim (2007) to investigates the effects of the 1997 financial crisis on the efficiency of eight Asian stock markets and found that the crisis adversely affected the efficiency of most Asian stock markets, with Hong Kong being the hardest hit.

The test of random walk of stock price is a test associated to the hypothesis of information efficiency in weak-form and not a direct test. Thus, the acceptance of a random walk hypothesis implies information efficiency, while the rejection is not synonym with information inefficiency. That is why the random walk tests should be accompanied by direct tests of information efficiency, such as tests of technical analysis. There have been a limited number of studies conducted on technical trading rules in the Asian-Pacific markets. Bessembinder and Chan (1995) were the amongst the first to report that the moving average and the trading range break-out rule have predictive ability in the emerging markets of Malaysia, Thailand and Taiwan but had less explanatory power in the more developed markets of Hong Kong and Japan. Ratner and Leal (1999) adapted the methodology of study the specific of emerging markets to take account of low trading and inflation. Thus, they examine the stock indices on 10 emerging markets in Asia and Latin America and the SP 500 and Nikkei 225 indices. Profitable strategies are focused mainly on markets from Mexico, Taiwan, Thailand and the Philippines. Tian, Wan and Guo (2002) explored the profitability of technical trading rules in U.S. and China stock markets. In the case of the U.S. the rules are not profitable after 1975, whereas for Chinese markets are profitable across the 1990's. Charlie and Keasey (2005) extend the analysis to other developed markets – namely, the U.K., Hong Kong and Japan. The results show that after 1990 the profitability of trading rules on the Chinese market decline progressively.

Most studies apply separately random walk and technical analysis tests to assess the degree of efficiency of financial markets. One of the few exceptions is the study realized by Lagoarde-Segot and Lucey (2006) who chose their combination path by constructing an index of efficiency to assess the relative efficiency for seven emerging Middle-Eastern North African stock markets. In this context it presents an interest the possibility of combined methodology windows, such as the random walk tests with technical analysis tests. Such a request was made by Todea (2008) on the Romanian market, as well as Todea et al. (2009) on six developed markets from Europe. These studies demonstrate that the profitability of technical analysis strategies is an episodic one and is given by the episodic behaviour of linear dependencies and, in particular, by non-linear dependencies. According to these results, one can say that the degree of market efficiency varies in a cyclical fashion over time and these statistical features are in line with those postulated by the Adaptive Markets Hypothesis (AMH) of Lo (2004). This article aims to investigate to what extent the obtained results on the European markets can be extrapolated to the Asian capital markets.

The remainder of the paper is structured as follows. Section 2 discusses the methodology employed. Section 3 provides a description of the data and Section 4 analyses the empirical results and assesses their significance. Finally, Section 5 concludes succinctly the implications of the results and the contribution of the paper in the area of research.

2. Methodology

The methodology applied in this paper is similar to that used by Todea (2008) on the Romanian market or by Todea et al.(2009) on six developed European markets. This consists of the study of the profitability of the moving average strategy over linear and nonlinear correlation windows, as well as over non-correlation windows. These windows are identified using an improved variant of the "windowed" methodology recommended by Hinich and Patterson (1995), in the rolling sample approach. Such a different reading was used by (2007) in ranking market efficiency for stock markets or by Lim et al. (2007) in investigating the effects of the 1997 financial crisis on the Asian stock markets. As a matter of fact, Todea and Zoicaş-Ienciu

(2008) showed that the original Hinich-Patterson methodology can be suspected of inaccurate identification of sub-periods exhibiting linear/nonlinear dependencies, because the test results depend on how the first day of the sample is chosen.

Correlations identification is made using the portmanteau test (C) for linear correlations and the bi-correlation test (H) for the nonlinear ones. In the rolling sample approach, C and H statistics are computed for the first window of a specified length (n), and then the sample is rolled forward eliminating the first observation and including the next one for re-estimation of C and H statistics. The procedure is repeated until the last observation of the sample is used. The return sample $\{R(t)\}$ is considered to be the realization of a stochastic process, where t (integer) is the time unit. In each window the data is standardized to have a sample mean of zero and a sample standard deviation of one, as follows:

$$Z(t) = \frac{R(t) - m_R}{\sigma_R} \tag{2.1}$$

where t takes values from 1 to n and m_R, σ_R are the mean and standard deviation within each window. The null hypothesis is that $\{Z(t)\}$ is the realization of a white noise process with null correlations and bi-correlations, described by $C_{RR}(r) = E[R(t)R(t+r)]$ and $C_{RRR}(r,s) = E[R(t)R(t+r)R(t+s)]$, where r and s are integers satisfying $0 < r < s < L$ with L being the number of the lags. The correlations and bi-correlations are then given by: $C_{RR}(r) = (n-r)^{-1/2}\sum_{t=1}^{n-r} Z(t)Z(t+r)$ and $C_{RRR}(r,s) = (n-s)^{-1}\sum_{t=1}^{n-s} Z(t)Z(t+r)Z(t+s)$ for $0 \leq r \leq s$.

C and H statistics are distributed according to a χ^2 law of probability with L respectively $(L-1)(L/2)$ degrees of freedom, having the following formulas:

$$C = \sum_{r=1}^{L} [C_{RR}(r)]^2 \tag{2.2}$$

and

$$H = \sum_{s=2}^{L}\sum_{r=1}^{s-1} G^2(r,s) \tag{2.3}$$

where $G(r,s) = (n-s)^{1/2} C_{RRR}(r,s)$.

Lim and others (2007) draw attention upon the fact that the determination of H bi-correlation statistics requires a prior filtration of the linear component, for which reason, this study filters out the autocorrelation structure by an autoregressive $AR(p)$ fit. The AR fitting is employed as a pre-whitening operation, and not to obtain a model of best fit. The p order of the $AR(p)$ model is chosen between 0 and 10 as the smallest value for which the Ljung-Box $Q(10)$ statistic is insignificant at the 10% level. Brooks and Hinich (2001) showed that it is not necessary to filter the returns through an AR-GARCH model in order to determine the statistics of the bi-correlation test, because the presence of GARCH effects will not cause a rejection of the null hypothesis of pure white noise. C statistics are being computed on the basis of unfiltered returns, meanwhile H statistics are computed inside each window on the basis of the unfiltered residuum resulted in pursuance of the linear component filtration. The null hypothesis of linear/nonlinear correlation is accepted or rejected in each window at a risk level of 1%.

The number of lags (L) is specified as $L = n^b$, with $0 < b < 0.5$. Hinich and Patterson based on Monte-Carlo simulation recommends the usage of $b = 0.4$ in order to maximize the power of the test assuring at the same time a good asymptotical approximation. The window length must be large enough to offer a robust statistical power and yet small enough for the test to be able to identify the arrival and disappearance of transient dependencies, as changes in the variables behavior. Despite the fact that in the previously mentioned studies the window's volume was of 50 or even 35 trading sessions, in this study we will employ windows of 200 observations, a volume that is recommended by Patterson and Ashley (2000) as a result of the Monte Carlo simulations achieved for six popular nonlinearity tests including the bi-correlation test.

The use of the moving average strategy is based on the fact that financial series are volatile and contain certain trends. The crossing of the prices or short term moving average line with the long term moving average line may be a sign that a trend has been initiated. Following this assertion a buying signal is generated when the short term moving average is higher than the long term moving average, and the selling signal is generated when the inequality is reverse. Around the long term moving average a percentage envelope has been introduced in order to eliminate contingent *« noisy »* signals. The majority of studies are limited to different moving average combinations proposed by Brock and others (1992), but taking into account that this variant is a restrictive one, a program has been developed that allows, for every market, the selection of the strategy for which the return in excess of the buy-and-hold strategy is maximum. This strategy is selected from 15000 strategies, number resulted as a combination of all variants of short term moving average (between 1 to 10 days) with all variants of long term moving average (between 50 to 200 days) and of 10 envelops comprised between 0,1% and 1% (multiple of 0,1%).

The commission for each transaction differs from market to market, being considered every time a selling or buying signal appears. In this study the investor is considered to be always on the market in a long or short position.

In each window of volume of 200 observations, the cumulated returns corresponding to the selected moving average strategy and to the buy-and-hold strategy have been computed, as well as the cumulated excess return. By dividing these results to 200 the daily average return/excess has been found and grouped together in 4 sub-samples depending on the results of the C and H tests. Considering the addition property of the average, the daily average excess was computed for each sub-sample and then the significance of each result has been tested. The daily average returns and the daily average excess returns have been annualized and expressed in percentage, by multiplying them with 250, respectively with 100 in order to offer a clearer image of the results.

3. The Data

The data consists of daily closing prices for six Asia-Pacific stock market indices from, July 1, 1997 to, April 14, 2008. Specifically, indices are collected for Australia (All Ordinaries Index), Hong Kong (Hang-Seng Index), India (BSE national Index), Malaysia (Kuala Lumpur Composite Index), Singapore (Strait Times Index) and Japan (Nikkei 225 Index). All the closing prices obtained from *Datastream* are denominated in their respective local currency units. The data is transformed into a series of continuously compounded percentage returns by taking 100 times to log price relatives, i.e. $r_t = \ln(p_t/p_{t-1}) * 100$, where p_t is the closing price of the index on day t.

4. Empirical Results

Running the program has allowed the identification for each market of the strategy for which the excess return from the buy-and-hold strategy to be full, (this finding is reported on the second column of Table 1). Determining the most profitable strategy was based on the closing prices of the indices for the period 7/01/1997 - 4/14/2008; but the profitability analysis of these strategies on linear / non-linear non-correlation and correlation sub-periods will be made on samples of different volumes depending on the value obtained for the long-term moving average. As an example, in the case of the Australian market, where the optimal strategy is (9, 62, 0.9%), the first 62 stock exchange meetings are waived from the initially sample. Thus, the first observation from the new sample corresponds to the 25-th of September 1997. The start date of the sample for each market is founded on the third column of Table I.

The results of Table I show that, with the exception of the Australian market, for any other market, the program could identify a strategy of moving average whose return is superior than buy-and-hold passive strategy. These results are obtained for a medium commission on transaction of 0.5%. The use of accurate commissions, specific to each market, may change to some extent the results, but such an approach is not necessarily required to achieve the objective study. In fact, it presents interest to what extent the profitability is higher in the sub-periods events of episodic dependencies than in sub-periods of acceptance of the random walk hypothesis.

With the exception of the Australian market, the annualized excess return of the optimum strategy comparative to the buy-and-hold strategy, lies between 4-13%. This excess varies over time depending on the evolutionary process of the stock market prices. One of the fundamental hypotheses of the moving average strategies is that the past tends to repeat itself. For this reason, the existence of an episodic behavior of the linear and nonlinear dependencies certainly influence their profitability over time.

Table II shows that the excess return inside the windows in which the random walk hypothesis is rejected due to linear and nonlinear correlations is superior to the excess return over the sub periods of acceptance of the random walk hypothesis, with the exception of the Japanese market. The percentage of windows in which the random walk hypothesis is rejected at a risk level of 1% varies from one market to another in an interval of 40-60%. This percentage is significantly influenced by the length of the window, which is 200 trading sessions in this study. Thus, the use of windows of 50 observations on Asian markets by Hinich (2005), Lim (2007) and Lim and others (2007) led to a percentage of windows in which are linear and nonlinear correlations of less than 20%.

Table III shows that the rejection of the random walk hypothesis is especially due to the presence of the nonlinear dynamics. In the case of markets from Australia, India, Singapore and Japan the moving average strategies exploit in particular non-linear correlations, a similar result to that obtained by Todea (2009) on market from Austria, Germany and UK. Nonlinear dynamics are used on markets from Hong Kong and Malaysia.

5. Conclusion

The contribution this study brings to the literature is the validation of the assumption under which the existence of episodes of dependency increases the degree of predictability of stock prices on six Asian equity markets. This ex-post validation is achieved through a combination of random walk tests (which are tests associated to the hypothesis of information efficiency in the weak-form), with direct tests of this hypothesis based on technical analysis.

The main conclusion is that the profitability of moving average strategies is not constant in time, but rather episodic showing when sub-periods of linear and non-linear correlation appear. Thus, it can be said that the degree of market efficiency varies in a cyclical fashion over time and these statistical features are in line with those postulated by the Adaptive Markets Hypothesis (AMH) proposed by Lo (2004, 2005). According to this theory, profit opportunities do exist from time to time.

The results obtained on the Asian markets consolidate those obtained on the European markets by Todea et al. (2009). They represent a strong argument for further research towards trying to anticipate the appearance of sub-periods of linear and non-linear correlation.

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Appendix

Table I. Optimal strategy, start date of sample, and returns

Country	**Optimal Strategy**	**Start date of sample**	**Buy-and-Hold return**	**Technical analysis return**	**Excess return**
Australia	(9, 62, 0.9%)	9/25/1997	0.000338*	0,000165*	-0,00017*
			(8,45%)	(4,125%)	(-4,325%)
Hong Kong	(3, 189, 0.9%)	4/14/1998	0,00045*	0,000608**	0,000158*
			(11,25%)	(15,20%)	(3,95%)
India	(1, 53, 0.7%)	9/16/1997	0,000643	0,00088	0,000237*
			(16,075%)	(22%)	(5,925%)
Malaysia	(7, 58, 0.4%)	9/23/1997	0,000331	0,001031	0,000653*
			(8,275%)	(25,775%)	(16,325%)
Singapore	(4, 84, 0.8%)	10/27/1997	0,000371*	0,000904*	0,000533*
			(9,275%)	(22,6%)	(13,325%)
Japan	(5, 159, 1%)	2/25/1998	0,0000033	0,000538*	0,000535*
			(0,084%)	(13,45%)	(13,375%)

Note: In the brackets are the annualized returns. Numbers marked with * (**) are significant at the 5% (1%) levels.

Table II. The average excess return generated by the optimum strategy over sub-periods of acceptance and rejection of the random walk hypothesis

		C and H insignificant		**C or H significant**	
Country	**Total number of windows**	**Number of windows**	**Excess return**	**Number of windows**	**Excess return**
Australia	2474	1336	-0,000396** (-9,9%)	1138	0,0000895* (2,24%)
Hong Kong	2279	1866	0,0000621 (1,55%)	413	0,000592** (14,8%)
India	2412	931	-0,00049** (-12,35%)	1481	0,000697** (17,425%)
Malaysia	2398	1025	0,000416** (10,4%)	1373	0,00083** (20,75%)
Singapore	2419	1346	0,000468** (11,7%)	1073	0,000613** (15,325%)
Japan	2290	1688	0,000531** (13,275%)	602	0,000546** (13,65%)

Note: In the brackets are the annualized returns. Numbers marked with * (**) are significant at the 5% (1%) levels.

Table III. The average excess return generated by the optimum strategy in the sub-periods of the random walk hypothesis rejection depending on the type of correlation

	C significant and H insignificant		**H significant and C insignificant**		**C and H significant**	
Country	**Nb. of windows**	**Excess return**	**Nb. of windows**	**Excess return**	**Nb. of windows**	**Excess return**
Australia	-	-	1071	0,000104* (2,6%)	67	-0,00015* (-3,75%)
Hong Kong	51	0,001829** (45,725%)	358	0,000419** (10,475%)	4	0,00027** (6,775%)
India	49	0,000569** (14,225%)	1263	0,000699** (17,475%)	169	0,000716** (17,9%)
Malaysia	10	0,001275** (31,875%)	848	0,000658** (16,45%)	515	0,001104** (27,6%)
Singapore	85	-0,0000329 (-0,823%)	941	0,000701** (17,525%)	47	0,000021 (0,53%)
Japan	35	-0,00023** (-5,775%)	548	0,00061** (15,25%)	19	0,000145* (3,625%)

Note: In the brackets are the annualized returns. Numbers marked with * (**) are significant at the 5% (1%) levels.