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Malaysian Banking Sector Efficiency, Structural Breaks and Cross-Sectional Dependence: Empirical Evidence

Kok Sook Ching[1], Qaiser Munir[2] and Arsiah Bahron[3]

This paper examines the weak-form market efficiency of the Malaysian commercial banks over the period of 17 October 1994 to 23 May 2014. We apply a powerful panel stationarity tests proposed by Carrión-i-Silvestre et al. (2005) that allow for the presence of multiple structural breaks and exploit the cross-section variation of the bank prices series. Our results indicate that all series can be characterized by a random walk process suggesting the bank stocks are weak-form efficient. We also find the evidence showing the presence of structural breaks and cross-sectional dependence (CSD) in the series. The results suggest that ignoring structural breaks and CSD can lead to biased estimates and spurious inference. The overall finding of this study is in favour of the weak-form efficiency. This finding has salient implications in terms of capital allocation, stock price predictability, forecasting technique, and the impact of shocks to stock prices.

Introduction

Investors in the stock market have a tendency to invest for short-horizon (over periods of days, weeks, or months) as well as to speculate, instead of simply buy-and-hold regularly or invest for long-horizon. Moreover, some analysts view the stock markets in developing countries as casinos that have little impact on economic growth (Levine 1996:7). In fact, the market which is largely occupied by short-horizon investors is exposed to the higher risk of capital inflow reversal. Radelet and Sachs (1998) reveal that Malaysia is amongst the Asian countries that has experienced the tremendous adverse impact from Asian financial crisis through the

[1] Universiti Malaysia Sabah Faculty of Business, Economics and Accountancy Kota Kinabalu, Sabah, Malaysia
[2] Corresponding author: Email: qaiser@ums.edu.myUniversiti Malaysia Sabah Faculty of Business, Economics and Accountancy Kota Kinabalu, Sabah, Malaysia
[3] Universiti Malaysia Sabah Faculty of Business, Economics and Accountancy Kota Kinabalu, Sabah, Malaysia

withdrawals of foreign capitals aftermath to the crisis. In particular, technical analysis hints that stock prices or returns are somewhat predictable. Technical analysts perceive a stock series will enrol in trends and these trends tend to repeat in future (see Dana and Cristina 2013). The tenet of chartist or technical theories is the assumption that historical stock price behaviour tends to recur in future, hence successive price changes are dependent and can predict the future movements of stock prices (Fama 1965). One famous technical theory is the Dow Theory. According to Ray (2012), Dow Theory holds that there are three main components in the movement of stock prices, namely, the primary trend or long-term trend which provides the grounds for bull and bear markets, the secondary trend which shows temporary reversal in the primary trend, and the daily fluctuations in stock prices are perceived meaningless. On the other hand, the weak-form efficient market hypothesis (EMH) is the assertion that stock prices fully reflect the information contained in the history of past trading (Bodie *et al*. 2008). This is consistent with the theory of random walks which states that stock price changes would have no memory and cannot predict the future movements of prices in a meaningful way (Fama 1965).

Mostly the past studies of weak-form EMH in the context of Malaysia are prominence to the stock market efficiency at the aggregate level by using the data of FTSE Bursa Malaysia KLCI (FBMKLCI) index prices, for examples, Lim *et al*. (2005), Lim (2008), and Munir and Kasim (2009). Firm-level disaggregation is crucial to pinpoint the efficiency and inefficiency for individual stocks. However, there are only a handful of past studies that focus on bank stocks in Malaysia. One example is the study of Lim (2007) which concentrates on four selected bank stocks. Several other past studies have employed the data envelopment analysis (DEA) method to study the relationship between technical efficiency and bank stock returns, including Habibullah *et al.* (2005), Sufian (2006), Sufian and Majid (2007), and Sufian and Haron (2009). Nevertheless, these studies are more towards the semi-strong form EMH. Currently, the current literature cannot provide a clear consensus on this matter. Bank stocks efficiency is more predominant compared to the stocks from other sectors. Banks act as the traditional financial intermediaries that match the borrowers and savers in an economy. They play an important role in allocating capital among all the productive real sectors. Levine and Zervos (1998) provide evidence showing bank credit predicts the growth in output, capital stock, and productivity. FitzGerald

(2006) claims that banks have remained as the key element in the financial system, especially when we consider most of the non-bank financial intermediaries are owned by banks. Moreover, the role of banks is extended to asset management and fee-based services.

The EMH is widely known for having pivotal implications in terms of resource allocation, the predictability of stock prices, trading strategy, forecasting techniques, and the effect of shocks to stock prices. First, from the standpoint of policy makers, efficiency is essential for enabling an effective allocation of capital among the productive real sectors through the stock market. When the market is efficient, share prices provide accurate signals to guide the investment decision-makings of all market participants, including firms and households. Efficiency is an incentive for investing in the stock market because investors are convinced that they can trade shares at a fair value. Thus, an efficient market can attract more investments and potentially contribute in fostering a more rapid economic growth. Otherwise, an economy can suffer the costs of inefficiency in the stock market. These costs are such as higher information costs and excessive share price fluctuations (Hubbard 2008). Second, the implication of the EMH is the unpredictability of stock prices. According to Fama (1965), competition in the market causes the full effect of new information is reflected instantaneously by the actual stock prices. The immediate stock price adjustment implies that successive price changes of stocks will be independent. Thus, an efficient market is similar to a random walk market, in which the theory of random walks posits that stock price series has no memory and historical stock prices cannot forecast the future in a meaningful way. In particular, the weak-form EMH asserts that stock prices already fully reflect the information contained in the history of past trading (Bodie *et al*. 2008), thus the information of historical prices cannot predict the future prices. Third, the EMH has an implication on trading strategies. It implies that speculation is risky and it is wiser to adopt a simply always buy-and-hold policy. Technical analysis is ineffective under the weak-form EMH because stock prices fully reflect the information of past trading. Fourth, if the series of stock prices can be characterized by random walks, then the effect of shocks on the prices is permanent. That means the prices will reach a new equilibrium and the future prices cannot be forecasted based on the past movements in prices (Narayan and Smyth 2004; Narayan and Narayan

2007; Munir *et al*. 2012). On the contrary, if stock prices are mean reverting shocks to the prices will have a temporary or transitory effect.

Specifically, the aim of this study is to examine the data generating process for the stock prices series of all commercial banks currently listed at the Malaysian stock exchange over the period of 17 October 1994 to 23 May 2014, in order to gauge the weak-form market efficiency for the Malaysian banking sector. We employ an array of unit root tests, including univariate and panel unit root tests, and the panel stationarity tests proposed by Carrión-i-Silvestre *et al.* (2005) which allows for the presence of multiple structural breaks and exploit the cross-section variation of the stock prices series. According to Baltagi (2001), panel data analysis allow for heterogeneity in individual, firms, regions and countries, which is absent when using aggregated time series data. We simultaneously consider structural breaks and CSD which have not received much attention in previous panel based studies of the EMH in the context of Malaysia. The Malaysian bank stocks are evidently affected by the Asian financial crisis. Most of the bank stock prices series exhibit major dips during the crisis period, 1997-1998 (as depicted in Figure 1 in Appendix A). In addition, Lim (2008) has provided evidence showing the efficiency of Malaysian finance sector has significantly declined during the crisis, 2 July 1997-31 August 1998. It is possible that there are other extreme events which have caused structural breaks in the series. Meantime, there are strong reasons to believe that CSD exists among the selected commercial banks. Firstly, commercial banks are highly interconnected in the domestic financial system. Secondly, as revealed by International Monetary Fund (IMF) (2014), in Malaysia, banks, non-bank financial institutions, and mutual funds are linked through the domestic wholesale funding market. From the empirical perspective, unit root test that does not take account of structural break will have low power (Perron 1989). Meanwhile, ignoring CSD can lead to biased estimates and spurious inference (Chudik *et al*. 2009). Therefore, our analysis incorporates structural breaks and CSD.

The rest of this paper is organized as follows: Section 2 provides a brief review of the empirical literature. Section 3 describes the dataset and presents the methodology. Section 4 is the summary and conclusion.

1. Literature Review

The weak-form EMH literature in the context of Malaysia is prominence to the efficiency of stock market at the aggregate level (Lim *et al*., 2005, Munir and Mansur, 2009, and Lim, 2008 among others). Lim *et al*. (2005) examine the data generating process of Kuala Lumpur Composite Index (KLCI) return series over the period of 2 January 1990-31 December 2002. Their study utilizes the Hinich and Patterson (1995) window testing procedure similar to the Box-Pierce Q-statistic to detect linear serial dependencies, and a biccorelation portmanteau test to detect non-linear serial dependencies. Their results indicate the presence of both linear and no-linear dependencies in the series. However, the correlations are found at random intervals for a short period of time, implying that they are episode and transient in nature. The authors conclude that the weak-form EMH and behavioural finance co-exists in the stock market of Malaysia.

Munir and Mansur (2009) investigate the behaviour of KLCI for the period of January 1980-August 2008, by using a two-regime threshold autoregressive (TAR) model with an autoregressive unit root to test for nonlinearity and nonstationarity simultaneously. Their result shows that, the index series is nonlinear and can be characterized by a unit root process. There is strong evidence provided by their study to support the weak-form EMH for the Malaysian stock market.

Lim (2008) examines the relative efficiency of eight economic sectors from the Malaysian stock market, including construction, consumer product, finance, industrial, industrial product, properties, tin and mining, and also, trade and service for the period of 1 January 1994 to 31 October 2006. The impact of Asian financial crisis on the sectoral efficiency is also examined. The study applies the rolling bicorrelation test statistic on the data of log index daily returns to detect nonlinear serial dependence in the series. The tin and mining sector is found to be the most efficient sector. Conversely, the properties sector is identified to have the most persistent deviations from random walk over time. All sectors except tin and mining experience the highest inefficiency during the crisis period, referring to the period of 2 July 1997-31 August 1998.

Bank stock efficiency has attracted little attention from researchers either in Malaysia or other countries. By comparison, researchers have paid more attention on the semi-strong form efficiency than the weak-form efficiency for bank stocks. This review captures a few past studies of semi-strong form EMH on bank stocks exclusively. Ioannidis *et al.* (2008) study bank stock returns and publicly available information by estimating the cost and profit efficiencies for 19 Asian and Latin American public listed banks, including 260 commercial banks, and bank holding companies, over the period of 2000-2006. In the finding, there is a robust relationship between the changes in profit efficiency with stock returns. It suggests that profit efficiency can better explain the returns of bank stocks than traditional profits measure such as the return on equity (ROE). More recently, Janoudi (2014) examines the relationship between cost and profit efficiencies of banks with the bank stock performance in the EU markets using a sample of 141 commercial banks, for the period of 2004-2010. The study employs the stochastic frontier analysis (SFA) to estimate the cost and profit efficiencies of the EU banking sectors, and investigates if the changes in cost and profit efficiencies are reflected in the annual stock returns of the banks. In the finding, both the changes in cost and profit efficiencies are found to be significant. Stocks with cost and profit efficiencies tend to outperform their inefficient counterparts.

In the context of Malaysia, there are a few previous studies that employ the data envelopment analysis (DEA) to study the relationship between technical efficiency and stock returns of the domestic banks. However, the evidence from applying such methodology will be related to a semi-strong form EMH (see Habibullah *et al*. 2005). For instance, Habibullah *et al*. (2005) utilizes the DEA method to compute the overall technical efficiency and to decompose it into pure technical efficiency, scale efficiency, and congestion efficiency. Then, the relationship between technical efficiency and the returns of selected bank stocks is analyzed. It is found that the percentage changes in stock prices reflect the percentage changes in the overall technical efficiency. The results suggest that the stock returns of Malaysian bank stocks are inefficient in the semi-strong form. The study by Sufian (2006) has investigated the efficiency of the Malaysian Islamic banking sector for the period of 2001-2004 by employing the DEA method. In the study, a sample of 15 domestic and foreign Islamic banks is used. Meantime, technical efficiency is decomposed into pure technical and scale efficiencies. The results show that scale efficiency dominates pure technical efficiency. Sufian and Majid (2007) investigate the X-efficiency and P-efficiencies of the Malaysian banks listed on the Kuala Lumpur Stock Exchange during the period of 2002-2003. From using the DEA method, the results indicate that the X-efficiency of the selected banks is on average significantly higher than the P-efficiency of these banks. In addition, the larger banks are associated with relatively higher X-efficiency, but the smaller banks with higher P-efficiency. Furthermore, the share prices of these banks are found to react more to the improvement in P-efficiency compared to X-efficiency.

Turning to the studies of weak-form EMH on bank stocks in particular, the empirical literature is obviously limited. There are only a handful of related past studies. Stengos and Panas (1992) examine both the weak-form and semi-strong form EMH for the four largest banks listed at the Athens Stock Exchange, namely Ktimatiki, Ergasias, Emporiki, and Ethniki, for the period of January 1985-October 1988. The data used are the daily closing prices of the bank stocks. The results from using the test developed by Brock, Dechert and Scheinkman (1987) do not show the evidence of linear or nonlinear dependence. Hence, the results can support the weak-form EMH. Furthermore, the results from cointegration and Granger causality tests refute the inefficiency in the semi-strong form. The overall finding of the study is in favour of the market efficiency for the selected bank stocks.

Bashir *et al*. (2011) have examined the weak-form EMH for 11 bank stocks from Karachi Stock Exchange over the period of June 1997-April 2009. The data applied in the study are the daily closing prices for the selected bank stocks. For estimation, the ADF and PP tests are utilized for stationarity check, and the co-integration and VAR tests are used to examine the weak-form EMH. The results of the study show the presence of predictable patterns in the stock prices, thus the results refute the EMH for the bank stocks. It is remarked that the market inefficiency may be caused by speculative bubbles.

In Malaysia, Lim *et al.* (2007) have addressed the question of whether stock prices follow a random walk process by using a sample of four commercial banks, namely, Hong Leong Bank, Malayan Banking, Public Bank, and Southern Bank, over the period of 1 January 1990 to 30 June 2004. He splits the data by utilizing the windowed-test procedure of Hinich and Patterson (1995), in which the data are separately into a set of non-overlapping windows of 30 trading days in length. The results show both $C$and H statistics are significant. In other words, there are linear and nonlinear dependencies in the stock returns. The results suggest that the stock returns are predictable to some extent. However, the predictable patterns are found to be non-persistence. The study provides finding that justify for the role of technical analysis. Nevertheless, the authors point out that it will be a challenge for analysts to develop specific trading rules which can exploit the predictable patterns discovered mainly because they are only short-term phenomenon. The importance of using the timing strategies is highlighted by the authors. Clearly, bank stock efficiency has not been given adequate research attention. Indeed, the study on this topic needs to be extended.

2. Data and Methodology

2.1 Dataset

We obtain the dataset of daily closing prices for ten Malaysian bank stocks from Datastream, including AFFIN (Affin Holdings Berhad), AFG (Alliance Financial Group Bhd), AMBANK (AMMB Holdings Berhad), BIMB (BIMB Holdings Bhd), CIMB (CIMB Group Holdings Berhad), HLBANK (Hong Leong Bank Berhad), HLFG (Hong Leong Financial Group Bhd), MAYBANK (Malayan Bank Berhad), PBBANK (Public Bank Berhad), and RHBCAP (RHB Capital Bhd). This study uses a balanced dataset covering the period from 17 October 1994 to 23 May 2014. We obtain a total of 5115 observations. The data of log prices are used for estimation. The series are displayed in Figure 1 in Appendix A and appear to be subject to several structural changes. We observe wild behaviours for all bank series around 1997, a time of Asian financial crisis. It seems that all the data sets contain many non-normal observations for which robust tests may be more appropriate than the usual tests.

2.2 Methodology

In this section, we briefly describe the test for the null hypothesis of stationarity that allows for multiple structural breaks in panel data developed by Carrion-i-Silvestre *et al*. (2005). This test generalizes the panel stationarity test of Hadri (2000) for the case of multiple changes in level and slope. It is written as follows:

$$U_{i,t} = \alpha_i + \sum_{k=1}^{m_i} \theta_{i,k} DU_{i,k,t} + \beta_i t + \sum_{k=1}^{m_i} \gamma_{i,k} DT^*_{i,k,t} + \varepsilon_{i,t} \quad (1)$$

Where $U_{i,t}$ represents banking stock prices of each individual banks i =1, . . . , N and t = 1, . . . ,T time periods; and $\varepsilon_{i,t}$ is the error term. In addition, The dummy variables $DU_{i,k,t}$ and $DT^*_{i,k,t}$ are defined as $DU_{i,k,t} = 1$ for $t > T^i_{b,k}$ and 0 otherwise; and $DT^*_{i,k,t} = t - T^i_{b,k}$ for $t > T^i_{b,k}$ and 0 otherwise; where $T^i_{b,k}$ denotes the kth date of the break for the ith individual, k =1,…, m_i, $m_i \geq 1$.

The specification in (1) is general enough to allow for unit-specific intercepts and linear trends in addition to unit-specific mean and slope shifts. To test the null hypothesis of a stationary panel, Carrioni-Silvestre *et al*. (2005) follows the Hadri (2000) procedure, which is constructed using a simple average of the univariate stationarity test in Kwiatkoeski *et al*. (1992) (KPSS hereafter). The test statistics is given by:

$$LM(\lambda) = N^{-1} \sum_{i=1}^{N} \left(\hat{\omega}_i^{-2} T^{-2} \sum_{t=1}^{T} \hat{S}^2_{i,t} \right) \quad (2)$$

Where $LM(\hat{\lambda}_i) = \hat{\omega}_i^{-2} T^{-2} \sum_{t=1}^{T} \hat{S}^2_{i,t}$ is the univariate KPSS test for individual i, and $\hat{S}_{i,t} = \sum_{j=1}^{t} \hat{\varepsilon}_{i,j}$ denotes the partial sum process that is obtained using the estimated OLS residuals from eq. (1), with $\hat{\omega}_i^{-2}$ being a consistent estimate of the long-run variance of $\varepsilon_{i,t}$. In this paper, we follow the procedure as in Kurozumi (2002) and estimate the long-run variance non-parametrically with the bandwidth of the Bartlett kernel fixed according to[4].

$$\hat{l} = \min\left\{ 1.1447\left(\frac{4\hat{a}^2 T}{(1+\hat{a})^2 (1-\hat{a})^2} \right)^{1/3}, 1.1447\left(\frac{4k^2 T}{(1+k)^2 (1-k)^2} \right)^{1/3} \right\}, \quad (3)$$

[4] Lee (1996) and Kurozumi (2002) suggest that the lag selection procedure in Andrews and Monahan (1992) should not be used to calculate the long-run variance for the KPSS test as it may leads to inconsistency in the test.

Where $\hat{a}$ is the autoregressive parameter estimated with the method proposed by Andrews (1991) and k = 0.7 is the preferred value according to Kurozumi's simulations that maintains a compromise between size and power performance.

Since the test is dependent on the vector λ_i = $(\lambda_{i,1,\ldots,}\lambda_{i,m_i})' = (T^i_{b,1}/T,\ldots,T^i_{b,m_i}/T)'$ for each i, which indicates the relative positions of the dates of the breaks on the entire time period (T), we estimate the vector λ_i for each unit using the procedure of Bai and Perron (1998) which is based upon the global minimization of the sum of squared residuals (SSR). The procedure is chosen as the location estimation of the breaks for the argument that minimizes the sequence of the unit-specific $SSR\left(T^i_{b,1}/T,\ldots,T^i_{m_i,1}\right)$ obtained from Eq. (1) such that:

$$(\hat{T}^i_{b,1},\ldots,\hat{T}^i_{b,m_i}) = \arg\min \mathrm{SSR}\ (T^i_{b,1},\ldots,T^i_{b,m_i}) \tag{4}$$

Having obtained the dates for all possible $m_i \leq m^{\max}$ for each i, where $m^{\max}$ is the maximum number of breaks, we select the appropriate number of structural breaks using the modified Schwarz information criterion (LWZ) of Liu *et al*. (1997), which is designed for the case of trending variables. Once the vector $\hat{\lambda}_i$ is determined, we compute the normalized test statistic as follows:

$$Z(\hat{\lambda}) = \frac{\sqrt{N}\,(LM(\hat{\lambda}) - \bar{\xi})}{\bar{\zeta}} \xrightarrow{d} N(0,1), \tag{5}$$

Where $\bar{\xi}$ and $\bar{\zeta}^2$ are computed as the respective averages of the individual means and variances of $LM_i(\hat{\lambda}_i)$. The computation of the $Z(\hat{\lambda})$ statistic requires the individual series to be cross-sectionally independent along with asymptotic normality. Since these assumptions may be overly simplistic, we compute the bootstrap distribution of the panel stationary test with multiple breaks following Maddala and Wu (1999) in order to allow for any kind of cross-sectional dependence, thereby correcting for finite-sample bias.

3. Empirical Results

3.1 Univariate Unit Root Tests

We begin the testing for unit root or stationarity by applying traditional univariate unit root tests. As depicted in Table 1 below, the unit root tests of Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) consistently indicate almost all series are integrated at order one, that is, the series are stationary in the first difference, which is a AR(1) model. However, in the levels, for the PBBANK the null hypothesis that the series has a unit root can be rejected at 5% level of significance.

Table 1: Results from the traditional univariate unit root tests

	ADF		PP	
	levels	1st diff	levels	1st diff
AFFIN	1.989	47.949*	2.006	70.078*
AFG	2.543	71.566*	-2.592	71.566*
AMBANK	-2.309	65.569*	-2.328	65.671*
BIMB	1.615	75.824*	1.540	76.095*
CIMB	2.633	67.733*	2.694	67.811*
HLBANK	2.632	47.016*	2.663	69.807*
HLFG	2.517	69.459*	2.546	69.469*
MAYBANK	2.470	71.298*	2.437	71.308*
PBBANK	3.444**	34.994*	3.391***	69.526*
RHBCAP	2.107	66.850*	2.116	66.843*

Note: *, ** and *** denote rejection of null at the 1%, 5% and 10% level, respectively.

3.2 Traditional Panel Unit Root Tests

Conventional unit roots tests for individual series (Augmented Dickey Fuller (ADF) and Phillips and Perron (PP), among others) are known to have low power against the alternative of stationarity of the series, particularly for small samples. In order to overcome this issue, we employ different panel tests (first generation), which differ in their treatment of the null hypothesis. For instance, the Breitung (2000) t-test and Levin *et al.* (LLC 2002) test specifies the null as a unit root and assumes common unit root processes. The Im *et al*. (IPS 2003) *w*-test and the ADF and PP Fisher chi-squared tests proposed by Maddala and Wu (1999) specify the null as a unit root but assume individual unit root processes. Finally, the Hadri (2000) z-test treats the null as no unit root and assumes common unit root processes.

The results from these panel unit root tests are presented in table 2. The results from LLC t-stat, Breitung t-stat and IPS w-stat indicate that we can reject the null hypothesis of unit root at least at the 5% level of significance. As opposed to foregoing test results, Hadri Z-stat provides result that can reject the null hypothesis of stationarity at the 1% level of significance, indicating the series are nonstationary or has a unit root. This result is consistent with the other two tests, ADF-Fisher Chi-square, and PP-Fisher Chi-square, which indicate the non-rejection of the null hypothesis of unit root for the series (see Table 2 below). To sum up, the results of three out of six tests indicating all the commercial bank series follow a random walk process, suggesting the bank stocks are weak-form efficient. Whereas, the results of other three panel unit root tests do not provide any evidence for the EMH. These contradicting results from the traditional panel unit root tests are due to the negligence of accounting for cross-sectional dependence and structural breaks[5].

Table 2: Results from traditional panel unit root tests

	T-statistics	**p-value**
LLC t-stat	-2.27193	0.0115
Breitung t-stat	-2.43686	0.0074
IPS w-stat	-1.8646	0.0311
ADF - Fisher Chi-square	27.7609	0.1152
PP - Fisher Chi-square	22.8612	0.2957
Hadri z-stat	71.4099	0.0000

Note: Above T-statistics and p-value are obtained using the automatic lag length selection based on AIC: 1 to 30.

[5] One reason for this result may be that during the last few decades we have experienced an ever-increasing economic and financial integration of banking sector and financial entities, which implies strong interdependencies between cross-sectional units. When applying the traditional unit root tests, who construct with the assumption of independence, ignore the issue of cross-section dependence and providing contradicting results as in our case. Thus, when dealing with the financial data which exhibit structural breaks and cross-sectional dependence, it may be possible that these tests will produce inconsistent results due to the negligence of these empirical aspects (see Carrion *et al*, 2005 on this issue). This is the issue we address in this study.

3.3 Test for Cross-Sectional Dependence

So far, the presentation of the panel statistics has assumed that individuals are cross-section independent. However, this assumption might be restrictive in practice since the analysis of macroeconomic time series for different banks are affected by similar major events that might introduce dependence among individuals in the panel data set. In many aspects the selected banks are related to each other, and it is very likely that these banks are simultaneously affected by common observed global shocks, such as financial crises (such as 1997-1999, 2008-2010), due to specific domestic or sectoral shocks or changes in oil prices. The presence of common shocks is likely to generate dependence among the units in the panel, although their impact may not be the same across different cross-section units. Therefore, we need to select panel unit root test that are robust to cross-section dependence in order to avoid size distortions of the tests.

Before deciding whether to allow for general forms of cross-sectional dependence when testing for a unit root in the series, we need to test for the prevalence of cross-correlation in innovations to the series. This is important because there are two main caveats associated with the presence or absence of cross-sectional dependence when testing for a unit root in a panel setting. First, traditional panel unit root tests which are derived under the assumption of cross-sectional independence are subject to large size distortions when there is a substantial degree of cross-correlation (see O'Connell 1998; Maddala & Wu 1999). Second, panel unit root tests allowing for cross-correlation suffer from substantial power losses when cross-sectional dependence is not present in the data.

In order to test the cross-section dependence among the individuals we use the CD statistic of Pesaran (2004). Pesaran (2004) proposed a simple test of error cross-sectional dependence which is suitable for both stationary and nonstationary panels under very general conditions. The cross dependence test is based on the average of pair-wise correlation coefficients of OLS residuals obtained from standard augmented Dickey–Fuller (1979, ADF) regressions for each individual. Let $\hat{\rho}_{ij}$ be the sample estimate of pair-wise correlation coefficients of OLS residuals such that:

$$\hat{p}_{ij} = \hat{p}_{ji} = \frac{\sum_{t=1}^{T} e_{it} e_{jt}}{\left(\sum_{t=1}^{T} e_{it}^2\right)^{1/2} \left(\sum_{t=1}^{T} e_{jt}^2\right)^{1/2}}$$

where e_{it} represents the OLS estimated residuals for individual i. Based on pair-wise correlation coefficients, Pesaran's test does not depend on any particular spatial weight matrix as is the case for the Breusch and Pagan (1980)'s LM test when the cross-sectional dimension (N) is large. The CD statistic in Pesaran (2004) is given by:

$$CD = \sqrt{\frac{2T}{N(N-1)}} \left(\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{p}_{ij} \right) \rightarrow N(0,1)$$

The Pesaran's *CD* statistic tests the null of cross-sectional independence and is distributed as a two-tailed standard normal distribution.

3.4 Cross-sectional Dependence Test Results

As clearly shown in Table 3, the CD statistic is highly significant for the commercial bank series, which implies that the null hypothesis that innovations to the variable are cross-sectionally independent is strongly rejected at the 1% significance level. Although it is not the case here, a possible drawback of the CD test is that adding up positive and negative correlations may result in failing to reject the null hypothesis even if there is plenty of cross-sectional dependence in the errors. In addition, the average absolute correlation is 0.871, which is a very high value. Hence, there is enough evidence suggesting the presence of cross-sectional dependence in the selected bank series. This result accords with our expectation regarding the high degree of cross-sectional dependencies across Malaysian commercial bank caused by common shocks.

Table 3: Cross-sectional dependence test results

	Statistics
H_0: *cross-sectional independence*	
CD test	23.610*
p-value	0.000
Average ($Pi_{,}j$)	0.871

Notes: The CD statistic tests for the null of cross-sectional independence and is distributed as a two-tailed standard normal distribution.* implies rejection of the null hypothesis at 1%.

3.5 Panel Stationarity Tests and Individual Tests with Structural Breaks

Since the data appear to be cross-sectionally correlated, we proceed by testing for a unit root using the methods that allow for cross-sectional dependence and incorporating structural break, i.e. second generation panel unit tests. There are different procedures in the literature to deal with cross-section dependence and structural break. In this paper we proceed with the application of panel stationarity tests proposed by Carrión-i-Silvestre *et al.* (2005) which allow for the presence of multiple structural breaks and exploit the cross-section variations of the series studied.

Table 4 reports the Carrión-i-Silvestre *et al.* (2005) panel stationarity unit root test that allows for endogenously determined multiple structural breaks and is flexible enough to control for CSD by accommodating the appropriate critical values by the bootstrapping procedure. In Panel A of Table 4, the last four columns show the computed 10%, 5%, 2.5% and 1% finite KPSS critical values, by means of Monte Carlo simulations of 20,000 draws. These critical values are used to control for the finite sample bias that might be present in small samples used in the paper. Comparing the observed KPSS statistics with the finite sample KPSS 1% critical values, we reject the null hypothesis of stationarity for all the series. Therefore, the series of these ten bank stocks are non-stationary, suggesting the market is efficient.

Comparing the observed panel KPSS test statistics, using the assumptions of homogeneous and heterogeneous variance, with the bootstrapped empirically distributed critical values at the 1%, 5% and 10% levels we reject the joint null hypothesis of stationarity. Specifically, for both the homogeneous and heterogeneous variance assumptions, we find the actual panel KPSS test statistics are greater than the bootstrapped critical values at the 1%, 5%, and 10% levels of significance. Thus, we can conclude that, after allowing for multiple structural breaks and controlled for CSD, the Malaysian bank stock series are nonstationary. Overall, the panel unit root test results are consistent with those of the individual country KPSS test results reported in Panel A of Table 4. From this exercise, we can conclude that the series contain unit root, suggesting the Malaysian bank stocks are efficient in the weak-form. These results are not consistent with Lim *et al.* (2007) and Bashir *et al.* (2011) who have found that bank stocks are not weak-form efficient, but are in line with Stengos and Panas (1992) who provide evidence showing bank stocks are weak-form efficient.

Table 4: Panel data stationarity tests and individual tests with structural breaks

Panel A:Country-by-country tests					
			Finite sample critical values (%)		
	KPSS	m	10%	5%	1%
AFFIN	0.034	5	0.015	0.017	0.021
AFG	0.035	4	0.021	0.023	0.029
AMBANK	0.035	5	0.016	0.017	0.021
BIMB	0.027	5	0.015	0.017	0.021
CIMB	0.041	5	0.016	0.018	0.022
HLBANK	0.036	5	0.015	0.017	0.021
HLFG	0.040	5	0.016	0.017	0.021
MAYBANK	0.036	5	0.016	0.017	0.022
PBBANK	0.033	5	0.015	0.017	0.021
RHBCAP	0.038	5	0.015	0.017	0.02
Panel B:Panel KPSS test with multiple breaks assuming cross-section independence					
		Test statistics	**p-value**		
LM(λ)(Homo)		23.316	0.000		
LM(λ)(Hetero)		22.739	0.000		
Panel C:Bootstrap distribution (Allowing for cross-section dependence)					
		90%	95%	99%	
LM(λ)(Homo)		7.095	8.198	10.425	
LM(λ)(Hetero)		4.376	5.336	7.25	

Note: The finite sample critical values were computed by means of Monte Carlo simulation using 20,000replications following Maddala and Wu (1999). All bootstrap critical values allow for cross-section dependence.

Table 5 reports the significant breakpoints identified from the bank stock prices series. The first common breaks for all series may correspond to the Asian financial crisis, 1997-1998. Malaysia has experienced the tremendous impact of the crisis through the rapid reversal of capital inflows aftermath to the crisis. This has led to a decline in the country's nominal and real exchange rates. In addition, interest rates are reduced accompanied by the tightening of credit conditions in the domestic market (see Radelet and Sachs 1998). The foregoing reflects a direct adverse effect on the domestic banks' credit activities as well as their profits. This can plausibly explain the breakpoints around the Asian financial crisis period. Meantime, there are a few other landmarks events which coincide with the breakpoints in the series. The breaks around the year 2000 possibly mark the event of Dotcom crash which has began in 2000 and lasts until 2002. Then, the breaks around the period of 2004-2006 are probably the consequence of the fluctuations in world crude oil prices. The recent breaks around the period of 2008-2011 may associate with several major global economic and financial turbulences, including the United States subprime mortgage crisis of 2008, the Great Recession of December 2007-June 2009, the European sovereign debt crisis of late 2009, and the 2011 global economic downturn. During the periods of these events, the level of risk aversion among stock market investors might have increased and thus causing significant changes in the stock market investment.

Table 5: Location of the breaks for each series

	$T_{b,1}$	$T_{b,2}$	$T_{b,3}$	$T_{b,4}$	$T_{b,5}$	
AFFIN	17/10/1997	26/9/2000	12/2/2004	3/7/2008	15/6/2011	
AFG	17/10/1997	26/9/2000	8/10/2003	23/9/2008	-	
AMBANK	22/10/1997	29/9/2000	28/3/2005	2/7/2008	10/6/2011	
BIMB	14/11/1997	24/10/2000	1/4/2005	27/6/2008	7/6/2011	
CIMB	17/10/1997	26/9/2000	4/9/2003	17/6/2008	26/5/2011	
HLBANK	17/11/1997	3/11/2000	7/4/2004	7/7/2008	15/6/2011	
HLFG	27/10/1997	12/12/2000	1/12/2003	8/11/2006	16/10/2009	
MAYBANK	22/10/1997	2/11/2000	13/10/2003	3/7/2008	13/6/2011	
PBBANK	1/10/1997	8/9/2000	25/12/2003	17/1/2007	25/12/2009	
RHBCAP	23/9/1997	1/9/2000	12/8/2003	15/1/2007	19/7/2010	

Summary and Conclusion

In this study, we examine the weak-form EMH for ten commercial bank stocks from Malaysia over the period of 17 October 1994 to 23 May 2014. To the knowledge of the authors, there has been no study examining the empirical validity of efficient market hypothesis of banking series by addressing the issue of cross-country dependence as well as multiple structural breaks.

We first demonstrate the use of comparative tests for unit root stationarity. The results from traditional univariate unit root tests of ADF and PP indicate the null hypothesis that the series has a unit root can be rejected at the 5% level of significance for almost all series, except PBBANK. Then, we apply traditional panel unit root tests to check the robustness of the results from univariate unit root tests. However, panel unit root tests, including Levin, LLC t-stat, Breitung t-stat, IPS W-stat, ADF-Fisher Chi-square, PP-Fisher Chi-square, and Hadri Z-stat provide mixed results of the nonstationarity of commercial bank stock series.

To date, there is a consensus that the traditional unit root tests have low power to reject the unit root null hypothesis when the true data generating process is stationary about a broken linear trend (Perron, 1989). Thus, ignoring structural breaks if present in the data is likely to produce spurious result. To address this issue, we apply the panel stationarity tests proposed by Carrión-i-Silvestre *et al.* (2005) that allow for the presence of multiple structural breaks and exploit the cross-section variations in the series. The result from KPSS test indicates multiple breakpoints for all the banking series. More importantly, the result from panel stationarity tests suggesting that we can reject the null hypothesis that the series is stationary at 1% level of significance for all series. Comparing the observed panel KPSS test statistics, using the assumptions of homogeneous and heterogeneous variance, with the bootstrapped empirically distributed critical values at the 1%, 5% and 10% levels we reject the joint null hypothesis of stationarity. Specifically, for both the homogeneous and heterogeneous variance assumptions, we find the actual panel KPSS test statistics are greater than the bootstrapped critical values at the 1%, 5%, and 10% levels of significance. We can conclude that, after allowing for multiple structural breaks and controlled for CSD, the Malaysian bank stocks series are nonstationary. Overall, the panel unit root test results are consistent with those of the individual country KPSS test results. These results confirm the nonstationarity of commercial bank stock series, implying the bank stocks are weak-form efficient.

The finding that the Malaysian banking sector is weak-form efficient has several salient implications. First, we expect that the commercial banks currently listed at the stock exchange in Malaysia will be able to raise long-term capital through their equity issues. The efficient bank stocks are relatively more attractive to investors as compared to their less efficient counterparts, because the prices of bank stocks provide accurate signals to guide the investment decision-making by investors. Thus, investors can buy and sell shares quickly and cheaply. Enhanced liquidity, therefore, smooth the investment in long-run for these commercial banks. Second, we foresee that the efficiency of these commercial banks are likely to contribute towards strengthening the banking sector's ability in complying with the International Regulatory Framework for Banks (Basel III) minimum capital requirements by 1 January 2019. The minimum equity tier 1 of 7 percent equals to minimum equity of 4.5 percent with capital conservation buffer of 2.5 percent. The banking group of Malaysia is expected to be able to comply with the minimum capital requirements in the low and baseline growth scenarios, but not in the high growth scenario (IMF 2014).[6] Malaysia is on the path of transformation into a high income country, hence it is crucial for the country to enhance the existing liquidity and capital standards of the banking sector. Third, as our finding indicates that the commercial bank stocks are weak-form efficient, suggesting investors will be better-off by simply buy-and-hold over the long-term investment horizon rather than by frequently trades over short-horizon or speculate. In particular, frequent buying and selling will incur higher transaction costs. Fourth, the finding in this study hints that technical analysis cannot be used to earn a consistent excess return from the market of these commercial bank stocks. Fifth, the weak-form efficiency of the commercial bank stocks signals that the effect of shocks to stock prices is permanent. If stock prices follow a random walk or unit root process,

[6] Low growth scenario reflects yearly real gross domestic product (GDP) growth of 2 percent, inflation of 1 percent, and loan growth of 3.6 percent; Baseline growth scenario indicates yearly real GDP growth of 5 percent, inflation of 2.5 percent, and loan growth of 8.2 percent; High growth scenario is associated with yearly real GDP growth of 6.5 percent, inflation of 4 percent, and loan growth of 12.2 (IMF, 2014).

shocks to prices will have a permanent effect in which a new equilibrium can be attained, implying that past sequence in prices cannot be used to predict future prices (Narayan and Smyth 2004; Narayan and Narayan 2007; Munir *et al*. 2012)

Lastly, we suggest for future studies to investigate different aspects of return predictability for bank stocks exclusively, such as the momentum and seasonal effects, and so forth. Long-run anomalies can be a violation to the EMH (Fama 1998), therefore it is crucial to identify the presence of persistent stable predictable patterns in a stock price series.

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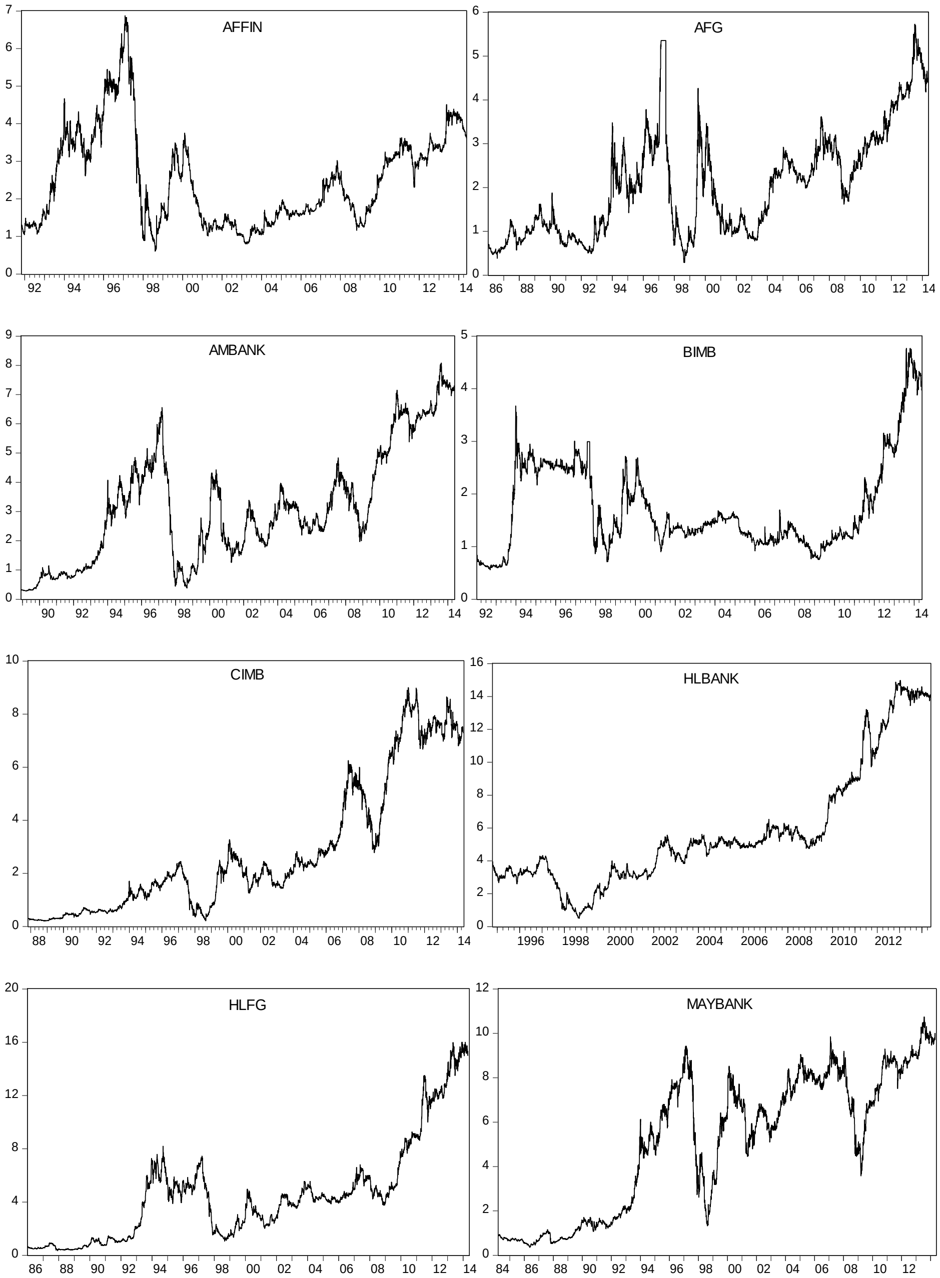
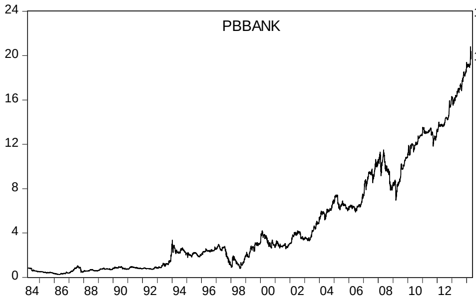
Appendix A

Figure 1: Selected Malaysian commercial banks stock prices




PBBANK
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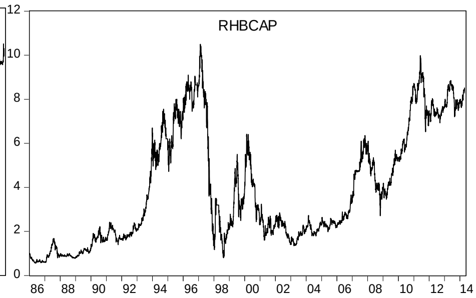
RHBCAP
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