Unexpected Volatility Shifts and Efficiency of Emerging Stock Market: The Case of Malaysia
Elgilani Eltahir Elsharei1, Hui-Boon Tan2 and Mei-Foong Wong3

Abstract
This paper analyzed the behavior of Malaysian stock market during the intervals of high uncertainty. It highlighted the impact of unexpected volatility shifts on this small emerging Asian market, in terms of its efficiency and returns, during the past two decades. The purpose of this study was achieved through the Iterated-Cumulative-Sum-of-Squares-in-Volatility model (ICSS-EGARCH-M Model), which is one of the new approaches in market efficiency studies. The empirical results indicated the rejection of Efficient Market Hypothesis for the market when sudden volatility shifts were considered. The results also provided significant empirical evidences for positive risk-return relationship in the exchanges. In addition, the stock market was found to be more sensitive to global than local events. The asymmetrical responses to good and bad news were also part of the market behavior.

Key words: Efficiency, Volatility, Malaysian stock market, EGARCH-M, ICSS algorithm

INTRODUCTION
The Asian financial markets have experienced several unexpected volatility shifts during the last two decades, for example, the eruption of the 1997-98 East-Asian financial turmoil that has elevated the uncertainties in the region. As one of the consequences, the Malaysian equity market, among others, has also experienced a great unexpected shift in the financial volatility. During that period, the volatility of the Kuala Lumpur Stock Exchange (KLSE) increased tremendously with investors’ confidence being badly damaged. This was reflected in a substantial decline in the key benchmark Kuala Lumpur Composite Index (KLCI). This high volatility shift in the stock market received a great deal of attention from economists and market participants, including investors, brokers, dealers, and regulators. High level of uncertainty reduced investors’ confidence and delayed their investment decision. The final impact was the delay of investment and economic growth.

It has been a well known fact that understanding the behavior of stock market volatility is important to both policy-makers and market practitioners. Policy-makers are mainly interested in the main determinants of volatility, its spillover effect on real economic activity and for assessing regulatory proposals to restrict international capital flows. On the other hand, Market practitioners, are mainly interested in the direct effects that time-varying volatility exerts on the pricing of financial assets and hedging strategies.

It is now widely noted that time-varying properties of the volatility of financial asset returns, which were conventionally measured by its variances and covariances, are no more constant over time; instead they evolve over time. Thus the assumption of constant variances over time is no longer valid. One of the most prominent tools that emerged to capture such time varying variances was the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) family approach, which have long been documented and modeled (see Bollerslev, 1986; and Bollerslev et al., 1992).

Volatility is considered highly persistent if a shock to a given system is permanent, and the past volatility can be used in constructing forecasts of future volatility. However, tranquil periods where prices are more or less stable could be followed by relatively high volatility periods characterized by large price changes due to economic, political and/or social events, both regionally or globally. These sudden changes in uncertainty, or volatility, should be given substantial concern as they can be persistence and have serious impact on asset prices as well as economic fundamentals. In view of this, we have surveyed the related literature, and found out that although the studies on the 1997-Asian-financial crisis and 2007-
global financial crisis were extensive, studies pertaining to the effect of sudden changes in volatility on the efficiency of Asian emerging stock market during the two crises were scarce and did not receive much attention.

In this case study, a great interest was focused on the effect of sudden volatility change on the stock price level of a small emerging Asian stock market - the Malaysian market. This study concentrated on the Kuala Lumpur Stock Exchange Composite Index (KLCI) and four sector indices. These sector indices were the plantation (PLT), Properties (PROP), Industrial (IND), and Finance (FIN). As an emerging stock market, the Kuala Lumpur stock exchange (KLSE) has received a great attention from researchers and investors. It has been regarded as one of the potential investment alternatives and its development is deemed rapidly growing (see Hooy et al., 2004) in the Asia-Pacific region.

It is important to note a few significant milestones of the market. First, the market has undergone financial liberalization since 1980’s. Secondly, it experienced a gradual improvement in terms of costs reduction and returns increment of the equities, and thirdly, its market efficiency has been subsequently influenced and uplifted by the authorities during the past two decades (see Kawakatsu and Morey, 1999). Besides, the market has adopted international standard and practices for its financial and non-financial disclosure, which in turn may have improved the informational efficiency of the market.

Obviously the East Asian emerging stock markets have been rocked by several sudden shifts in the volatilities. These sudden shifts encompass the 1997-Asian Financial Crisis and 2007- Global Financial Crisis, which had recorded a serious impact on these markets. In view of this, more empirical findings should be learned and documented from the crises for future benefits. As one of the affected countries, Malaysia was chosen as a case to provide empirical insight on the matter. There were two studies, namely, Law (2006) and Goh et al. (2005) have looked into the volatility and structure breaks of the Malaysian stock market. While Law (2006) only investigated the increment of volatility of the Malaysian stock prices during the Asian Financial Crisis period, Goh et al. (2005) only examined the structural breaks in the market and related it to the rest of the ASEAN markets. Thus, more in-depth studies related to this issue are still timely and required, in particular those address the impact of 2008-2009 Global Financial Crisis and 2010-2011 European Debt Crisis.

By focusing on one of the Asian emerging stock markets, the Bursa Malaysia, this paper examined the effect of sudden shifts in unconditional variance of five Malaysian stock prices on the efficiency of the market. With the similar purpose, the effect on the risk-returns relationship in the market was also analyzed. These sudden changes in volatility were identified endogenously using the iterated cumulative sums of squares (ICSS) algorithm developed by Inclan and Tiao (1994). To our knowledge, this approach has not been employed in research works pertaining to the Malaysian stock market, particularly in investigating the effect of large sudden shifts of volatility on the performance of the market. For other Asian stock markets, the Japanese and Korean markets were studied, by Wang and Moore(2009). In another recent study, Kang et al. (2009) have investigated five Central European stock markets. According to their empirical estimations, when sudden shifts of volatility were included in the GARCH model, the persistence of volatility was reduced significantly in each of the five markets. Based on the results, they have suggested that many previous studies may have overstated the degree of volatility persistence in financial time series, and highlighted the importance of capturing volatility shifts in the model.

The reminder of this paper is organized as follows. Section 2 presents an overview of the stock market efficiency hypothesis. Section 3 describes the data and methodology. Section 4 reports the empirical results and section 5 is the concluding remarks.

**STOCK MARKET EFFICIENCY**

The Efficient Market Hypothesis (EMH) describes an efficient market as one where security prices fully and speedily reflect available information (see Fama, 1970). The content of any new information becoming available will be quickly digested by market participants and if the information causes them to change their opinion of the security’s intrinsic value, their subsequent action will rapidly cause an

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4However, their study, based on GARCH approach, is incapable of integrating sudden changes and is also unsuitable for examinations of volatility persistence (see Nwogugu, 2006).
equivalent change in the security’s market price. To examine the adjustment of security prices to a precise
definition of information, the EMH takes three forms depending upon the extent of the information
deemed available to market participants. These forms are defined as the weak form efficiency, Semi-
strong efficiency and strong-form efficiency.
The EMH has attracted researchers, investors and policy makers, particularly in emerging markets. In
major markets like the London and New York stock exchanges, the evidence has in favor of the EMH,
especially at the weak and semi-strong form levels (see Fama, 1991). The emerging markets, on the other
hand, indicate significant departures from the Efficient Market Hypothesis (see Omet et al., 2002). Given
the large volume of research already existed for mature stock markets, it is interesting to examine
whether Malaysian security prices fully and speedily reflect the available information in the emerging
stock markets, especially in the presence of sudden changes in unconditional variance shifts.

DATA AND METHODOLOGY

Data
The data employed by this study consisted of the weekly closing stock price index of Kuala Lumpur
Composite Index (KLCI), plantation (PLT), Properties (PROP), Industrial (IND), and Finance (FIN).
Weekly rather than daily data were chosen to avoid the potential biases associated with micro-structural
issues, non-trading, the bid-ask spread effect in daily data, and problems of thin trading which were often
associated with most emerging markets. All stock prices series were collected from DataStream and
spanned from June 1990 to June 2011, which include both the Asian Financial Crisis and Global Financial
Crisis. The stock market returns were calculated according to the following expression:

\[ r_t = (\log S_t - \log S_{t-1}) \times 100 \]  

Where \( \log S_t \) was the natural logarithm of the index at time (week) \( t \). Dividends were assumed away (see
Campbell et al., 1997).

Methodology
It is widely recognized that the GARCH family models are standard and widely used for stock market
volatility analyses. However, the standard GARCH models overestimate the persistence of volatility
when sudden shifts of unconditional variance are observed in the data (See Lastrapes, 1989). Therefore,
sudden variance changes, which characterize most of Malaysian stock prices, must be taken into account
when modeling volatility by employing the GARCH family models.

In examining the volatility behavior of the Malaysian stock prices, it is observed that all Malaysian stock
prices exhibited high fluctuation which was followed by low fluctuation in several periods. In addition, it
was found that several structural breaks, outliers, extreme observations were mostly associated with
sudden changes in unconditional variance in the sample period. All these have undesirable effects on
Maximum Likelihood estimation.

Our survey on the literature found a strand of research that highlighted the existence of severe excess
kurtosis in their estimated residuals. This excess kurtosis can be originated from aberrant observations
like structural changes and outliers. Franses and Ghijsels (1999) proposed a methodology to detect and
correct additive outliers (AO) within the GARCH framework. On the other hand, Charles and Darné
(2005) extended the Franses-Ghijsels methodology by incorporating innovative outliers (IO) into the
GARCH family models. Another school of thought employed Iterative Cumulative Sum of Squares (ICSS)
algorithm advocated by Inclan and Tiao (1994) to detect sudden shifts in unconditional variance. The
detected sudden shifts were incorporated into the variance equation of GARCH model using appropriate
dummy variables. For example, Wilson et al. (1996) used this approach for oil futures series; Malik (2003)
employed it for exchange rates; Hammoudeh and Li (2008) employed it for the Gulf Arab equity markets;
Kang et al. (2009) employed it for the Japanese and Korean equity markets; and Wang and Moore (2009)
employed it for the European equity markets.

It is important at this point to note that even though Nelson’s (1991) exponential GARCH, or EGARCH
model is robust in capturing asymmetric effects of volatility, the model, however, by itself may not be
able to capture all of the variance effects when there is(are) sudden shift(s). It was also noted by several
previous study that conditional heteroskedastic models tend to overestimate the persistence of volatility
when there are instabilities at the unconditional second moment. Therefore, it is crucial to include the
breakpoints of sudden shifts in variance that can capture some of the time-varying volatility or breaks in the volatility process. In order to estimate the number of shifts in variance and the point in time of each variance shift, the ICSS algorithm procedure proposed by Inclan and Tiao (1994) is employed. The algorithm focuses on identifying an unconditional variance change due to a sudden shift that changes the variance during a time interval. The approach was proven to be an effective tool in detecting sudden changes in variance of a time series.

To begin with the algorithm, let \( r_t \) be the stock price return series with unconditional variance \( \sigma^2 \). The variances within each interval were given by \( \tau^2_i \), \( i = 0, 1, \ldots, N_T \). Here, \( N_T \) was the total number of variance changes in \( T \) observations and \( 1 < k_1 < k_2 < \ldots < k_{N_T} < T \) were the change points. It can be clearly denoted as \( \sigma^2 = \tau^2_i \) for \( 1 < t < k_1 \); \( \sigma^2 = \tau^2_i \) for \( k_1 < t < k_2 \); \ldots, \( \sigma^2 = \tau^2_i \) for \( k_{N_T} < t < T \).

The above variance changes could be identified via the following steps. First, the Iterative-Cumulative-Sum-of-Squares of the series were produced using \( S_k = \sum_{t=1}^{k} \tau^2_t \) for \( k = 1, \ldots, T \). Secondly, a dummy variable \( \psi_k \) was set up as

\[
\psi_k = (\xi_k / \xi_T) - (k/T), \quad k = 1, \ldots, T \quad \text{with} \quad \psi_0 = \psi_T = 0. \quad (2)
\]

If there was no significant shift in the variance, \( \psi_k \) oscillated around zero and would exhibit a horizontal line when plotted against \( k \). If there was a significant shift in the variance, on the other hand, \( \psi_k \) would drift upward and downward around zero when plotted against \( k \). In this case, sudden changes in variance were detected using the critical values which are given in table 1 of Inclan and Tiao (1994). The significant changes were detected using the critical values obtained from the distribution of \( \sqrt{T/2} |\psi_k| \), where \( \psi_k \) was multiplied by \( \sqrt{T/2} \) to standardize the distribution. To identify significant changes we examined the standardize \( \sqrt{T/2} |\psi_k| \) series instead of the \( \psi_k \) series. The null hypothesis of homogeneous variance can be rejected, if the maximum of \( \sqrt{T/2} |\psi_k| \) exceeds the critical value. Let \( k^* \) denote the value at which \( \max_k \sqrt{T/2} |\psi_k| \) reached. If \( \max_k \sqrt{T/2} |\psi_k| \) falls outside the predetermined boundary, then \( k^* \) is taken as a point in unconditional variance shift. Frequently \( \psi_k \) function alone is insufficient to detect multiple variance shifts at different intervals due to the so called ‘masking effect’. The ‘masking effect’ means that moderate variance shifts may not be detected due to the existence of large variance shifts. This problem is resolved by the ICSS algorithm by evaluating the \( \psi_k \) over different time intervals. The algorithm is thus based on successive evaluations of \( \psi_k \) at different parts of the series, dividing consecutively after a possible change point is found. Once the breakpoints have been identified using the algorithm, the next stage is to construct the EGARCH-M model which incorporated the identified variance shifts.

The extended Iterated-Cumulative-Sum-of-Squares-in-Volatility model (ICSS-EGARCH-M Model), which incorporates sudden shifts of volatility in the EGARCH(p, q)-M Model was formulated as:

\[
r_t = \pi_0 + \sum_{i=1}^{p} \pi_i r_{t-i} + \epsilon_t + \sum_{j=1}^{q} \theta_j \epsilon_{t-j} + \phi \sqrt{h_t} \\
\epsilon_t |\phi_{t-1} \sim \text{GED} \quad (3)
\]

\[
\log (h_t) = \omega + \sum_{i=1}^{p} \alpha_i \left( \frac{\epsilon_{t-i}}{h_{t-i}} \right) + \sum_{i=1}^{q} \gamma_i \frac{\epsilon_{t-i}}{h_{t-i}} + \sum_{j=1}^{q} \beta_j \log (h_{t-j}) + d_1 S_1 + \ldots + d_n S_n \quad (5)
\]

where \( r_t \) represented respective weekly stock return, \( \epsilon_t \) was the market innovation or residuals, \( h_t \) was the respective conditional variance of the returns process based on the information set \( (\phi_{t-1}) \) of relevant and available past data; \( \omega, \beta, \gamma \) and \( \alpha \) were parameters to be estimated, \( S_1 \cdots S_n \) were dummy variables taking a value of 1 for each breakpoint of sudden shift of variance and 0 otherwise. The conditional variance was asymmetrical, if the estimated leverage-effect term, \( \gamma \), was significantly different from zero \( (\gamma \neq 0) \). Parameters in the variance equation (Equation 5) were obtained through the maximum likelihood estimation, namely the Marquardt method with robust standard errors. The adequacy of the EGARCH-M model was examined by employing three standard diagnostic tests, namely the Ljung Box Q-statistic and Jarque-Berra statistic in detecting any possible autocorrelation and non-normality of the standardized residuals; the ARCH LM test, in addition, was employed to detect whether the standardized residuals exhibited any autoregressive conditional heteroskedasticity (ARCH) effect.
EMPIRICAL RESULTS
Based on Table 1 which reported the descriptive statistics for the five indices, a number of observations can be made. First, during our sample period from June 1990 to June 2011, all the Malaysian stock prices have a positive mean return, with the Properties Index demonstrated a higher return than the others. Secondly, the standard deviation, which measured stock return volatility, indicated that the Properties Index has the highest value of 1.56%, among all. Thirdly, Returns from KLCI and all the other four sectors displayed positive skewness. All the coefficients of skewness reported in Table 1 indicated that stock returns in Bursa Malaysia were positively skewed and not normally distribution. Fourthly, the kurtosis values for all the five indices exceeded 3, indicating a leptokurtic distribution. The Jarque-Bera (JB) statistic reported in the fifth column of Table 1 confirmed the significant departure of these stock returns from normal distribution, which was similar to the findings of Kang et al. (2009), Wang and Moore (2009), even though these previous analyses were done on other markets. In view of this, any hypothesis testing on the process of returns generation in this emerging market will be limited as the returns were not normally distributed.

Insert table 1 here
In Table 2, the detected sudden shifts in the stock market were listed. It was found that most of the sudden shifts of variance for all indices, either the general main listing or sector listing, occurred around similar break positions over time. In this study, we managed to identify the events that might have caused the break positions, or sudden shifts in volatility for returns in the main market and sectoral market. It was found that sudden changes in volatility of these transactions were caused by both global and regional events, since the Malaysian stock market was quite integrated with others globally. These events included: huge portfolio capital inflows in 1993, massive capital flight in early 1994, the 1997–98 Asian Financial Crisis; the 11 September 2001 catastrophe; the 2003-04 US-Iraq war and Severe Acute Respiratory Syndrome (SARS) outbreak, the 2005-06 political crisis in Thailand and East Timorese Crisis, the 2007 sub-prime mortgage crisis; the US financial crisis of 2008; the 2008-09 Global Financial Crisis; and the recent European Debt Crisis of 2010-11. In general, these sudden shifts in variance indicated asymmetrical responses of the market to positive and negative news.

Insert table 2 here
Table 3 reported the estimated ICSS-EGARCH-M model estimation. To assess the descriptive validity of the model, the Ljung-Box Q statistics were calculated for serial correlation in standardized residuals, and squared standardized residuals. All series were found to be free of serial correlation using the squared standardized residuals. The ARCH-LM test suggested in general the absence of heteroskedasticity in the residuals. The absence of serial correlation in the standardized squared residuals implied that the model was well specified.

The significant $\pi_i$ across any indices (in column 2 – 5 of Table 3) implied a departure from the Efficient Market Hypothesis, where past information can be used to improve future predictability of prices or returns. This result was consistent with that of Marshall and Cahan (2005). It indicated that small emerging Malaysian market, which is quite in isolation from major markets, is not attractive to hedge funds and other professional investors, and thus inefficiencies were not trade away, as those happened in larger and developed markets. In addition, prohibition of short-selling in Malaysia during the sample period also formed an environment where inefficiencies were more likely to persist. The departure from the Efficient Market Hypothesis during the sample period also reflected the chaotic financial environment in the market. The market was affected significantly by various news events, in particular those pertaining to the crises. Under these chaotic market conditions, investors tend to overreact not only to local news, but also to news originated from other international markets.

It was observed that the estimated risk coefficient $\varphi$ (St. Dev.) of conditional variance was significant in all the five sectors. In other words, a positive and significant association was found between risk and return in all cases of these stock sectors. This implied that, in general, an investor in the Malaysian stock market, who bears risk, will be compensated with a higher return.

The $\gamma$ coefficient, on the other hand, revealed whether asymmetric news impacts have been observed. The estimated results reported in Table 3 indicated that the estimated $\gamma$ coefficients of Kuala Lumpur Composite index and industrial index were statistically significant, indicating the presence of
asymmetrical news effects across the main listing and industrial sector. It seemed that negative price shocks led to considerably higher volatility in stock returns as compared to positive shocks. In addition, the estimated value of coefficient $\beta_i$ ($i = 1, 2$) of all the five indices displayed rather low persistence to volatility shocks. These findings were consistent with those reported by Kang et al. (2009) for the case of another small emerging Asian stock market - the Korean stock market.

Insert table 3 here

CONCLUDING REMARKS
This paper examined the efficiency of an emerging stock market, namely the Malaysian stock exchanges, in terms of its returns and conditional volatility in the presence of sudden shifts in unconditional variance vis-à-vis an Iterated-Cumulative-Sum-of-Squares-algorithm-in-volatility (ICSS-EGARCH-M) model. Our empirical results, after accounting for sudden shifts of volatility, still indicated a significant departure from the Efficient Market Hypothesis for the main and all the four stock sectors. Among all, the general index for the main market – KLCI and the sector index – Industrial, were the most inefficient. The results also provided significant empirical evidence for positive risk-return relationship in the exchange. Moreover, this study also found that the stock market, across all sectors, was more sensitive to global news events as compare to the local ones. The asymmetrical responses to good and bad news were also an important characteristic of the Malaysian market behavior.

REFERENCES


Table 1. Summary statistics for the Malaysian stock market weekly returns

<table>
<thead>
<tr>
<th></th>
<th>KLCI</th>
<th>Finance</th>
<th>Industrial</th>
<th>Plantation</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.0012</td>
<td>0.0016</td>
<td>0.0013</td>
<td>0.0016</td>
<td>0.0019</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>0.0129</td>
<td>0.0147</td>
<td>0.0126</td>
<td>0.0138</td>
<td>0.0156</td>
</tr>
<tr>
<td>Skewness</td>
<td>2.1998</td>
<td>2.3142</td>
<td>3.4857</td>
<td>1.1366</td>
<td>2.7368</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>30.4179</td>
<td>30.1676</td>
<td>45.8603</td>
<td>24.4249</td>
<td>31.9140</td>
</tr>
<tr>
<td>Jarque-Bera (P-value)</td>
<td>34346.01</td>
<td>33829.48</td>
<td>83988.27</td>
<td>20676.11</td>
<td>38572.14</td>
</tr>
<tr>
<td>Observations</td>
<td>1069</td>
<td>1069</td>
<td>1069</td>
<td>1069</td>
<td>1069</td>
</tr>
</tbody>
</table>

Notes: Skewness measures the asymmetry of the distribution of the series around its mean. The skewness of a normal distribution is zero. Kurtosis measures the peakness or flatness of the distribution of the series. The kurtosis of the normal distribution is 3. If the kurtosis exceeds 3, the distribution is leptokurtic, and if less than 3 platykurtic relative to the normal distribution.

Table 2. Detected changes in variance based on the ICSS Algorithm procedure

<table>
<thead>
<tr>
<th>Important change points</th>
<th>Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>KLCI</td>
<td>Prior to the Gulf war</td>
</tr>
<tr>
<td></td>
<td>Huge portfolio capital inflows</td>
</tr>
<tr>
<td>10/29/1993</td>
<td>Massive capital flight</td>
</tr>
<tr>
<td>06/04/1993, 12/24/1993,</td>
<td></td>
</tr>
<tr>
<td>01/28/1994, 01/06/1995,</td>
<td></td>
</tr>
<tr>
<td>03/17/1995</td>
<td></td>
</tr>
<tr>
<td>08/29/1997, 09/05/1997</td>
<td>Asian financial and currency crisis</td>
</tr>
<tr>
<td>09/21/2001</td>
<td>September 11 attacks</td>
</tr>
<tr>
<td>7/1/2004</td>
<td>The US-Iraq war and Severe Acute Respiratory Syndrome (SARS) outbreak</td>
</tr>
<tr>
<td>11/17/2006</td>
<td>Political crisis in Thailand and East Timorese crisis</td>
</tr>
<tr>
<td>7/6/2007</td>
<td>US sub-prime mortgage crisis</td>
</tr>
<tr>
<td>Finance</td>
<td>Huge portfolio capital inflows</td>
</tr>
<tr>
<td>10/29/1993</td>
<td>Massive capital flight</td>
</tr>
<tr>
<td>01/14/1994, 01/06/1995,</td>
<td></td>
</tr>
<tr>
<td>03/17/1995</td>
<td></td>
</tr>
<tr>
<td>08/22/1997, 9/12/1997</td>
<td>Asian financial and currency crisis</td>
</tr>
<tr>
<td>08/14/1998, 09/11/1998</td>
<td>Russian financial default</td>
</tr>
<tr>
<td>10/15/1999, 3/30/2001</td>
<td>Internet bubble</td>
</tr>
<tr>
<td>09/21/2001</td>
<td>September 11 attacks</td>
</tr>
<tr>
<td>6/3/2004</td>
<td>The US-Iraq war and Severe Acute Respiratory Syndrome (SARS) outbreak</td>
</tr>
</tbody>
</table>
Political crisis in Thailand and East Timorese crisis  
US sub-prime mortgage crisis  
Global financial crisis and deleveraging activities in the advanced economies  
European debt crisis  
Huge portfolio capital inflows  
Massive capital flight  
Asian financial and currency crisis  
Russian financial default  
Internet bubble  
September 11 attacks  
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Russian financial crisis  
Internet bubble  
September 11 attacks. The invasion of Iraq  
The US-Iraq war and Severe Acute Respiratory Syndrome (SARS) outbreak  
Political crisis in Thailand and East Timorese crisis. The energy shock by rising oil prices  
US sub-prime mortgage crisis  
Global financial crisis and deleveraging activities in the advanced economies
Table 3. The estimates of ICSS-EGARCH-M parameters

<table>
<thead>
<tr>
<th></th>
<th>KLCI</th>
<th>INDUSTRIAL</th>
<th>FINANCE</th>
<th>PLANTATION</th>
<th>PROPERTIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi_0$</td>
<td>0.9701(0.000)</td>
<td>0.9498(0.000)</td>
<td>0.9471 (0.000)</td>
<td>0.9440(0.000)</td>
<td></td>
</tr>
<tr>
<td>$\pi_1$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.8464(0.000)</td>
</tr>
<tr>
<td>$\pi_2$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\pi_3$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\theta_1$</td>
<td>-0.9816(0.000)</td>
<td>-0.9559(0.000)</td>
<td>-0.9445 (0.000)</td>
<td>-0.9477(0.000)</td>
<td></td>
</tr>
<tr>
<td>$\theta_2$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.8173(0.000)</td>
</tr>
<tr>
<td>$\theta_3$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\varphi$ (St. dev.)</td>
<td>0.1287(0.000)</td>
<td>0.1009(0.000)</td>
<td>0.1217 (0.000)</td>
<td>0.0463(0.051)</td>
<td>0.0691(0.047)</td>
</tr>
<tr>
<td>$\omega$</td>
<td>-4.1737(0.005)</td>
<td>-5.2794(0.000)</td>
<td>-2.2509(0.000)</td>
<td>-5.7589(0.000)</td>
<td>-9.7346(0.002)</td>
</tr>
<tr>
<td>$\alpha_1$</td>
<td>0.1205(0.121)</td>
<td>0.2252(0.009)</td>
<td>0.0005(0.992)</td>
<td>0.2740(0.003)</td>
<td>0.0931(0.275)</td>
</tr>
<tr>
<td>$\gamma_1$</td>
<td>-0.0991(0.048)</td>
<td>-0.1564(0.006)</td>
<td>0.0030(0.939)</td>
<td>-0.0590(0.377)</td>
<td>0.0411(0.497)</td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>0.5767(0.000)</td>
<td>0.4559(0.000)</td>
<td>0.7481(0.000)</td>
<td>0.4218(0.005)</td>
<td>-0.0928(0.792)</td>
</tr>
<tr>
<td>$d_1$</td>
<td>0.5794(0.004)</td>
<td>0.7120(0.011)</td>
<td>0.6277(0.005)</td>
<td>-1.1104(0.058)</td>
<td></td>
</tr>
<tr>
<td>$d_2$</td>
<td>0.5312(0.034)</td>
<td>-0.7291(0.011)</td>
<td>0.6277(0.005)</td>
<td>-1.1104(0.058)</td>
<td></td>
</tr>
<tr>
<td>$d_3$</td>
<td>1.2993(0.085)</td>
<td>0.5602(0.023)</td>
<td>-1.7980(0.018)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$d_4$</td>
<td>-1.4775(0.052)</td>
<td>-0.6387(0.004)</td>
<td>-0.6974(0.008)</td>
<td>1.1302(0.081)</td>
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</tr>
<tr>
<td>$d_5$</td>
<td>0.8702(0.001)</td>
<td>1.7729(0.000)</td>
<td>2.5019(0.018)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$d_6$</td>
<td>-0.3668(0.063)</td>
<td>-1.2396(0.002)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>$d_7$</td>
<td>4.5799(0.001)</td>
<td>0.9124(0.010)</td>
<td>-1.4089(0.079)</td>
<td>4.1831(0.014)</td>
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</tr>
<tr>
<td>$d_8$</td>
<td>-3.5331(0.004)</td>
<td>-1.0181(0.004)</td>
<td></td>
<td>-3.6452(0.014)</td>
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</tr>
<tr>
<td>$d_9$</td>
<td></td>
<td>-0.2329(0.042)</td>
<td></td>
<td>-3.6452(0.014)</td>
<td></td>
</tr>
<tr>
<td>$d_{10}$</td>
<td>-0.5388(0.026)</td>
<td>-0.5798(0.008)</td>
<td>0.2724(0.069)</td>
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</tr>
<tr>
<td>$d_{11}$</td>
<td>-0.5470(0.013)</td>
<td>-0.6264(0.003)</td>
<td>-0.3991(0.021)</td>
<td>1.5287(0.023)</td>
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</tr>
<tr>
<td>$d_{12}$</td>
<td>-0.3784(0.031)</td>
<td>-0.2166(0.019)</td>
<td>-1.7935(0.013)</td>
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</tr>
<tr>
<td>$d_{13}$</td>
<td>0.7119(0.011)</td>
<td>0.2407(0.014)</td>
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</tr>
<tr>
<td>$d_{14}$</td>
<td></td>
<td>0.6778(0.021)</td>
<td>0.8627(0.050)</td>
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<tr>
<td>$d_{15}$</td>
<td>1.9356(0.000)</td>
<td>-0.8021(0.009)</td>
<td>-1.3111(0.009)</td>
<td>-1.5419(0.009)</td>
<td></td>
</tr>
<tr>
<td>$d_{16}$</td>
<td>-1.3285(0.001)</td>
<td></td>
<td>0.6253(0.039)</td>
<td>0.7227(0.088)</td>
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</tr>
<tr>
<td>$d_{17}$</td>
<td>-0.5949(0.013)</td>
<td></td>
<td>-0.9731(0.011)</td>
<td>1.4386(0.017)</td>
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</tr>
<tr>
<td>$d_{18}$</td>
<td>-0.7034(0.008)</td>
<td></td>
<td>1.1018(0.002)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$d_{19}$</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$d_{20}$</td>
<td></td>
<td></td>
<td></td>
<td>0.9737(0.024)</td>
<td></td>
</tr>
<tr>
<td>$d_{21}$</td>
<td></td>
<td></td>
<td></td>
<td>-1.1470(0.012)</td>
<td></td>
</tr>
<tr>
<td>$d_{22}$</td>
<td></td>
<td></td>
<td></td>
<td>-0.8487(0.034)</td>
<td></td>
</tr>
</tbody>
</table>

AIC         -6.5530 -6.5760 -6.2154 -6.3126 -6.1001
SIC         -6.4646 -6.5016 -6.1083 -6.2241 -6.0022
Log-likelihood 3518.32 3527.62 3342.07 3389.94 3272.39
Q(20)        18.51(0.422) 11.30(0.881) 25.33(0.116) 13.86(0.738) 21.48(0.256)
Q^2(20)      15.12(0.653)  9.89(0.935) 10.70(0.906) 26.73(0.084)  9.76(0.939)
ARCH LM test 0.9015(0.585) 0.5759(0.931) 0.4041(0.991) 1.2968(0.171) 0.5590(0.940)

Notes: p-values were reported in the parenthesis. Q(20) and Q^2(20) were the Ljung-Box Q statistics for residuals and standardized squared residuals at lag 20. The optimal structure of ARCH LM test was detected at lag 20. The empty cells in the table denoted non-applicable of the respective independent variables.