ARCH AND GARCH BASED TESTS ON THE MALAYSIAN STOCK MARKET, INTEREST RATE AND EXCHANGE RATE BEFORE AND DURING THE CURRENCY TURMOIL.

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ABSTRACT.

This paper attempts to investigate the volatility of the Malaysian financial markets before and during the Southeast Asian currency crisis. The objective of this study is to provide some information on the behaviour of three important financial variables namely the stock market, interest rate and exchange rate which have been badly affected by the crisis. Using the GARCH (1,1) models, the paper investigates the volatility of the three variables before and during the Southeast Asian currency crisis. The results of this study suggest that only KLCI has the ARCH effect before the turmoil but all the variables have the ARCH effect during the turmoil. The results of GARCH(1,1) model indicate the presence of GARCH effects in all the variables before and during the turmoil except for KLIBOR for the period before the turmoil. It is also discovered that the persistency of the volatility for individual variables implies a permanent impact on future volatility. However, when two other variables squared returns are introduced, the coefficients for all individual variables reduced significantly with the exception of KLCI. Therefore, the persistency of the volatility may imply a transitory impact on future volatility or the volatility may decay with time. It also suggests that the persistency of the coefficient for each variable can also be explained by information from the other two variables.

INTRODUCTION

The Malaysian financial market has experienced one of its worst episode in history as a result of the currency crisis that hit the Southeast Asian countries. Its currency, Ringgit, has slumped to its worst level ever, depreciated by over 60 percent against the US dollar. This is followed by the declined in the stock market where the KLSE Composite Index recorded 286 points in October 1998 which is the lowest ever in the last ten years. The interest rate skyrocketed at the initial stage of the crisis before the government, through a new leadership at the central bank, abandoned the IMF-style recovery

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actions and instead introduced a much talk-about policy of fixed exchange rate that eases the interest rate.

The drastic fluctuations of financial asset prices in Malaysia as evident during the crisis highlight the importance of understanding the volatility of financial asset prices. Perhaps, it is now becoming a crucial if not the most important challenge for investment analysts in recent times. Many studies attempt to model the pattern of volatility for financial assets due to its vast contribution in asset pricing. Successful estimation of volatility of the underlying stocks, for instance, will enable investors to make informed decisions when engaging in dynamic trading strategies. Aggregate stock market volatility can also be a useful indicator since it tends to be unusually high in times of recessions and financial crises.[1] Understanding the volatility of the foreign exchange rates can also assist in making important decision for international capital budgeting. In addition, foreign exchange volatility plays an important role in currency related derivatives pricing.

Given the increasing importance of understanding volatility, this paper attempts to investigate the volatility of the Malaysian financial markets before and during the financial crisis. The objective of this study is to provide some information on the behaviour of three important financial variables namely the stock market, interest rate and exchange rate which have been badly affected by the crisis. GARCH (Generalised Autoregressive Conditional Heteroscedasticity)- models, the paper intends to study the volatility of the three variables before and during the Southeast Asian currency crisis. The findings could serve as a guide for practitioners in the event of repeat history.

BACKGROUND OF THE STUDY

Previous studies on time series properties of volatility often resort to the ARCH family models to estimate volatility. The original ARCH model, proposed by Engle (1982), estimates the return volatility or the conditional variance which is assumed to be a function of the past history of squared forecast errors of the conditional mean. The conditional density is assumed to be normally distributed. Bollerslev (1986) extends the ARCH model by re-specifying the conditional variance equation to incorporate more information and with a more flexible lag. He discovers that his model, GARCH provides a more parsimonious model and gives a slightly better fit than the original ARCH.

The ability of both models to accurately capture and predict the dynamics of time series has been

[1] *See Tang and Gannon (1997) for a brief discussion on previous findings.*

tested on various financial assets and markets. Among the studies on foreign exchange, Copeland and Wang (1994) apply the GARCH to determine the forecasting model for exchange rates. They combine the time- and frequency-domain analysis to improve the modelling of seasonal patterns in daily exchange rate changes. They also estimate the day-of-week effect in spot returns on five exchange rates against the US dollar. The result seems to compare favourably with those from a pure time-domain GARCH approach. It is found that the most volatile time occurs on Thursday and this can be attributed by the US practice of announcing the weekly money supply figures on every Thursday.

Alexander (1995) investigates the common ARCH factors for weekly and daily US dollar and German mark returns to several currencies using the Engle and Kozicki (1993) common features methodology. It is found that the daily returns are too noisy to reveal any common ARCH factors for US dollar while no evidence is detected for German mark for both weekly and daily returns. However, there is a strong evidence of a common ARCH factor is found in sterling and US dollar weekly returns which is attributed to the speculative investment. Surprisingly, no evidence of common ARCH factor in German mark and Guilder returns despite their GARCH similarities which is attributed to the lack of dynamic structure in the tests proposed by Engle and Kozicki.

West and Cho (1995) examine the out-of-sample forecasting performance of univariate homoscedastic, GARCH, autoregressive and nonparametric models for conditional variances using five bilateral weekly exchange rates for US dollar from 1973 to 1989. They find that GARCH models tend to make slightly more accurate forecast for a one week horizon. However, it is difficult to find grounds for choosing between various models since none of them perform well in a conventional test of forecast efficiency.

McKenzie (1997) compares the ability of ARCH, autoregressive and mean models to forecast the magnitude of change in twenty one Australian bilateral exchange rate series. The results of the study suggest that ARCH models generate superior forecasting performance in daily and weekly frequency data. The optimal model is found to be sensitive to the choice of performance indicator. All models perform reasonably well in a conventional test of forecasting efficiency.

Wang and Wong (1997) employ the Kalman filter and ARCH models to account for time-varying parameters and conditional variances to provide evidence on long-horizon predictability of exchange rates. The findings show that for long forecasting horizon (6 to 12 months), the Kalman filter and/ or ARCH models generally outperform the naïve random-walk for Singapore dollar and Japanese yen. The two techniques even outperform the OLS and AR(1) forecasts.

Many studies on conditional volatility of the stock market have also adopted the ARCH class models. Brailsford and Faff (1996) employ the daily Australian stock market index to examine the superiority forecasting models which include ARCH and GARCH models. The results suggest that ARCH class of models and a simple regression model provide superior forecasts of volatility. However, the various model rankings are shown to be sensitive to the statistic used to assess the accuracy of the forecasts. Interestingly, both conclude that "volatility forecasting is a notoriously difficult task".

Tang and Gannon (1997) examine the volatility of the Malaysian stock market by analysing both the market index and individual stock. The Exponentially-Weighted Moving Average (EWMA) model is evaluated against various extensions of GARCH model. The result show that the simple EWMA outperforms GARCH-class models in modelling market volatility, and neither market turnover nor leverage effects are significant for market index.

Alles (1998) examines the unconditional and the conditional volatility of the daily and monthly returns of the Sri Lanka stock market. He discovers that the unconditional volatility of the market surged in 1990, possibly due to the entry of foreign investors to the market. Adopting three models ARCH, GARCH and EGARCH (Exponential GARCH) to estimate the conditional volatility, he notices that ARCH model performed best for the monthly series and the GARCH model performed best for the daily series.

Using GARCH, Davidson and Mackenzie (1998) consider the issue of currency attack against Malaysian Ringgit to assess whether the markets anticipate the currency attack. The evidence from GARCH suggests that the market did not appear to foresee the attack despite the presence of some of the necessary conditions for a currency. Tan and Alles (1998) study the predictability of Australian interest rate volatility using four different models of GARCH and find that the GARCH model with contemporaneous volatility spillover is one of the superior models for forecasting interest rate volatility.

Given the popularity of the ARCH and GARCH models in previous studies on volatility, this study attempts to investigate their effects on the Malaysian stock market, interest rate and exchange rate before and during the currency turmoil.

DATA AND METHODOLOGY

This study uses Kuala Lumpur Stock Exchange Composite Index (KLCI) as a proxy for the stock market, Malaysian Ringgit (MYR) against US dollar (USD) which represents the exchange rate and the three month Kuala Lumpur Inter-bank Offered Rates (KLIBOR) which represents the interest rate. The time period covered are from January 1996 to June 1998 which is then divided into two sub-periods to represent the period before and during the currency turmoil. Data from January 1996 to June 1997 represent the former while the later is represented by the data from July 1997 to June 1998. All series are daily closing expressed in natural logarithmic form, and the change for each series is calculated as

$\ln\left(\frac{I_{s,t}}{I_{s,t-1}}\right)$ where I_t = value for series S; S = { KLCI, KLIBOR or MYR }

In this study we restrict our attention to a GARCH(1,1) specification only since it has been shown to be parsimonious representation of conditional variance that adequately fits many economic time series (e.g., Bollerslev (1987), Bera and Higgins (1992) and Tang and Ganon (1997)). Such a model is given below:

$$r_{s,t} = c + a_0 r_{s,t-1} + \varepsilon_t \quad (1)$$

where,

$$\varepsilon t|\Psi_{t-1} \sim N(0,\sigma_t^2) \quad (2)$$

and,

$$\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \beta_1\sigma_{t-1}^2 + \upsilon_t \quad (3)$$

The dependent variable r_s is return of series S; S = { KLCI, KLIBOR or MYR }. The term $a_0 r_{t-1}$ in equation (1) is used to account for any autocorrelation that may arise due to nonsynchronous trading (e.g., Koutmos and Saidi (1995) and Lo and MacKinley (1990)). The distribution of the stochastic error term is conditional on the realised set of variables and is assumed to be normal and described by the mean of zero with a changing variance of σ_t^2 which is the function of past squared errors. We employ Bollerslev and Woolridge's (1991) robust standard errors in all estimation to tackle the problem when the assumption of conditional normality is violated.

We also examine the effect of lag volatility of each series in the variance equation to see whether the information can be helpful in predicting the volatility of the dependant variable. We also assume that if the volatility has some information in explaining the persistency level, the persistency level should decrease when the volatility variable measured by r_s^2S = {KLCI, KLIBOR and MYR} is included in the variance equation. The standard GARCH(1,1) model is estimated but with the following modification to the conditional variance equation:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \phi_1 r_{s,t-1}^2 + \upsilon_t \qquad (4)$$

Where, r_s^2 is the squared returns either for series S; S= {KLCI, KLIBOR or MYR}.

As stated earlier, volatility persistence measured by $(\alpha_1 + \beta_1)$ will be examined to see the effect of the other two variables squared returns when it is included in the variance equation. A value of unity indicate that the volatility persistence is permanent whereas a value less than unity imply that past shocks will decay over time. Wald test is performed to test the null hypothesis of $_1 + \beta_1 =$ [2]

FINDINGS

Descriptive summary

Table 1 presents the summary statistics of raw data for all the variables. All the variables are more volatile during the turmoil as compared against the period before the turmoil. The high level of volatility is demonstrated by the increase level of standard deviation between both periods. In term of coefficient of variations, before the turmoil and during the turmoil, KLCI is the most volatile among the variables. While during the turmoil, MYR becomes more volatile than the KLIBOR than before the turmoil. Much of this can be associated with the excessive speculative activities during the turmoil.

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[2] *For details on the Wald Test procedure please refer to Johnston and Dinardo (1997) pg 148.*

TABLE 1: SUMMARY STATISTIC

	Before Turmoil		
	KLCI	**KLIBOR**	**MYR**
Mean	1158.558	7.426864	2.501033
Median	1140.740	7.350000	2.500000
Maximum	1271.570	8.760000	2.528000
Minimum	1041.270	7.240000	2.471000
Std. Dev	60.08291	0.229792	0.015582
Observations	370	370	370
Coefficient of variation (%)	0.05186	0.03094	0.00623
	During Turmoil		
	KLCI	KLIBOR	MYR
Mean	706.2085	9.587167	3.493170
Median	694.6925	9.240000	3.647500
Maximum	1082.625	14.90000	4.640000
Minimum	441.6950	7.450000	2.496000
Std. Dev	161.4467	1.393224	0.517249
Observations	246	246	246
Coefficient of variation (%)	0.22861	0.14532	0.14807

Volatility performance

Table 2 presents the results estimation of the GARCH(1,1) models for all the variables before and during the currency turmoil. The result of GARCH (1,1) model shows that only KLCI has significant relationship between the variance and the squared residual from yesterday before the currency turmoil. During the currency turmoil, all the variables have the ARCH effect. The result of GARCH(1,1) model shows that conditional variance today is significantly related to yesterday's conditional variance for all the variables except for KLIBOR before the currency turmoil.

TABLE 2. RESULT FOR GARCH (1,1) MODEL

Before Turmoil				During Turmoil		
Variable	Coef	T-stat	*P-value*	Coef	T-Stat	*P-value*
KLCI						
α_0	1.94E-06	1.289828217	0.19834165	8.24E-06	0.795422524	0.42715373
α_1	0.147203591	2.180719557	0.03016768	0.30272284	3.301688001	0.00110744
β_1	0.793174914	7.934530753	7.84E-14	0.76472167	13.48467757	3.16E-31
KLIBOR						
α_0	5.52E-06	1.114655561	0.2661038	1.70E-07	0.52781381	0.59811621
α_1	1.281333494	0.976245395	0.32991773	0.810221609	2.676918819	0.00794274
β_1	0.15772366	0.648197433	0.5174718	0.695065025	15.37726152	1.33E-37
MYR						
α_0	1.70E-07	1.443007455	0.15031149	7.22E-06	1.420710527	1.57E-01
α_1	0.146366527	1.492804828	0.13679083	0.140322587	2.411587462	0.01663507
β_1	0.779834809	8.291050786	7.81E-15	0.844543879	18.53055268	3.44E-48

Table 3 presents the results of the GARCH model for all the variables before and during the currency turmoil with other variables' squared returns (r_s^2) effect. The result shows that there are ARCH (past shocks) and GARCH (past variance) effect for MYR and KLCI before the turmoil when r_s^2 for KLCI and KLIBOR and KLCI and KLIBOR were added into the estimation process. It also shows the r_{klci}^2 significant effect to the MYR volatility. During the turmoil, all the variables have significant GARCH effects. It also shows that r_{myr}^2 and r_{klci}^2 have significant effect on KLIBOR. r_{klibor}^2 has also significant effect on KLCI volatility.

TABLE 3: RESULTS FOR GARCH (1,1) WITH SQUARED RETURNS OF OTHER VARIABLES SQUARED RETURNS EFFECT.

Before Turmoil

Volatility	α_0	α_1	β_1	ϕ_{klci}	ϕ_{klibor}
MYR	.24X10-7 (0.1590)	0.1889 (0.0087)*	0.6148 (0.0000)**	0.0069 (0.0137)*	0.00027 (0.5913)
				ϕ_{myr}	ϕ_{klci}
KLIBOR	1.01X10-6 (0.3266)	0.6473 (0.3248)	0.3438 (0.1444)	1.1843 (0.3184)	-0.0069 (0.1116)
				ϕ_{myr}	ϕ_{klibor}
KLCI	1.59X10-6 (0.3020)	0.1392 (0.0353)*	0.8118 (0.0000)**	0.0283 (0.8654)	-0.00122 (0.2208)

During Turmoil

Volatility	α_0	α_1	β_1	ϕ_{klci}	ϕ_{klibor}
MYR	6.63X10-6 (0.5412)	0.1894 (0.1426)	0.7941 (0.0000)**	0.0044 (0.7909)	-0.000161 (0.9033)
				ϕ_{myr}	ϕ_{klci}
KLIBOR	-3.10X10-6 (0.0000)**	0.15876 (0.0035)**	0.8163 (0.0000)**	0.01103 (0.0094)**	0.0223 (0.0000)**
				ϕ_{myr}	ϕ_{klibor}
KLCI	0.69X10-5 (0.0016)**	0.3606 (0.0056)**	0.4846 (0.0066)**	0.1009 (0.7909)	-0.0014 (0.0000)**

P-values are in the parenthesis

** Significant at the 1% level of significance

* Significant at the 5% level of significance

Table 4a shows the results of the persistency test for the coefficients of individual variable obtained from the GARCH model before and during the turmoil. Table 4b shows the results of the persistency test for the coefficients obtained from the GARCH model for individual variable when the other two variables are included before and during the turmoil. For the individual variables, only the coefficient for KLIBOR is greater than one before the turmoil. However, it is not significant. As for MYR, it is significantly smaller than one. During the turmoil, the coefficients of the GARCH model for all the variables are bigger than one with the exception of MYR. But none is significant. Therefore, the persistency of the volatility may imply a permanent impact on future volatility.

With the exception of KLCI, the coefficients of the GARCH model for all individual variables when two other variables squared returns are included, are significantly smaller than one for all variables before the turmoil. However, they are found to be significantly smaller than one during the turmoil. Therefore, the persistency of the volatility may imply a transitory impact on future volatility or the volatility may decay with time.

It can be observed that the coefficient of ARCH and GARCH for each of the variable is reduced or significantly smaller than one, when two other variables squared returns were introduced. Therefore, the persistency of the coefficient can also be explained by information from the other two variables, either the MYR, KLCI or KLIBOR.

Table 4a: The persistency test for the coefficient from the GARCH (1,1) model for individual variable before and during the turmoil.

	Before Turmoil			During Turmoil		
Variable	MYR	KLCI	KLIBOR	MYR	KLCI	KLIBOR
$\alpha+\beta$	0.926201	0.9404	1.439057	0.98487	1.067505	1.5052866
Chi-square Test Statistic	4.388584	0.400354	0.152751	0.25264	0.900626	1.415071
P-value	0.03618	0.526906	0.695920	0.873710	0.342614	0.234216

Table 4b: The persistency test for the coefficient from the GARCH (1,1) model for individual variable when two other variables squared returns are included before and during the turmoil.

	Before Turmoil			During Turmoil		
Variable	MYR	KLCI	KLIBOR	MYR	KLCI	KLIBOR
$\alpha+\beta$	0.8037	0.9510	0.9911	0.9835	0.8452	0.97506
Chi-square Test Statistic	123795.7	0.228141	9.717249	18842.52	29.18852	26.21291
P-value	0.00000	0.632906	0.001825	0.00000	0.00000	0.00000

CONCLUSION

The results of this study suggest that all the variables - stock market, interest rate and exchange rate, have the ARCH effect during the turmoil, but only KLCI has the ARCH effect before the turmoil. The results of GARCH model indicate the presence of GARCH effects in all the variables except for KLIBOR for the period of before the turmoil. This implies the nonlinearity of the distribution for the three variables particularly during the turmoil.

It is also discovered that the persistency of the volatility for individual variables implies a permanent impact on future volatility. However, when two other variables squared returns are introduced, the coefficients for all individual variables reduced significantly before the turmoil, with the exception of KLCI. Therefore, the persistency of the volatility implies a transitory impact on future volatility or the volatility may decay with time. The persistency of the coefficient for each variable can also be explained by the information from the other two variables. The findings are important to policymakers who should consider this factor when reviewing the price limit in the time of turmoil. Should the market experience another turmoil in the future, investors can benefit from this finding by incorporating the knowledge of financial asset volatility into asset pricing.

REFERENCES:

Alles, L. (1998) "Estimation of Stock Market Volatility in an Emerging Market: the Case of Sri Lanka". A paper presented at the 10th Annual PACAP/FMA Finance Conference. October 26th - 28th, 1998. Kuala Lumpur, Malaysia.

Alexander, C.O. (1995) "Common Volatility in the Foreign Exchange marker". Applied Financial Economics, Vol. 5, Iss. 1, pg. 1-10, Feb. 1995.

Bera , A.K. and Higgins, M.L. (1992). " Arch Models: Properties Estimation and Testing. *Journal of Economic Surveys"*, Vol 7, pg 305-366.

Bollerslev, T. (1986) "Generalised Autoregressive Conditional Heteroskedasticity". *Journal of Econometrics,* Vol. 52, pg. 307-327.

Bollerslev, T. and Wooldridge , J.M (1992)." Quasi-maximum Likelihood Estimation and Inference in Dynamic Models with Time-varying Covariances", Economic Reviews, Vol 11, pg 143-179

Brailsford, T.J. and Faff, R.W. (1996) "An evaluation of the Volatility Forecasting Techniques". *Journal of Banking and Finance,* Vol. 20, pg. 419-438.

Copeland, L.S. and Wang, P. (1994) "Estimating Daily Seasonality in Foreign Exchange Rate Changes". *Journal of Forecasting,* Vol. 13, Iss. 6, pg. 519 - 528, Nov. 1994.

Davidson, S. and McKenzie, M. (1988) "Was the Speculative Attack on the Malaysian Currency Anticipated by the Stock Market". A paper presented at the NFA/APFA First Joint International Conference. July 19-22, 1988, Tokyo, Japan.

Engle, R. F. (1982) "Autoregressive Conditional Heteroskedasticity with Estimates of Variance of UK Inflation". Vol. 50, pg. 987-1008.

Engle, R. F. and Kozicki, S. (1993) "Testing for Common Features". Journal of Business and Economic Statistics. Vol. 11, pg. 369-380.

Johnston, J. and DiNardo, J. (1997). "Econometric Methods". The McGraw-Hill. New York.

Koutmos, G. and Saidi, R. (1995). "The leverage Effect in Individual Stocks and The Debt To Equity Ratio", Vol 22, pg.1063-1075.

Lo, A.W and Mackinley, A.C (1990). " An Econometric Analysis of Nonsynchronous Trading", *Journal of Econometrics,* Vol 45. pg. 181-211.

McKenzie, M.D., (1997) "Forecasting Australian Exchange Rate Volatility". A paper presented at the 4th Asia Pacific Finance Association Conference, July 14th - 16th, 1997. Kuala Lumpur, Malaysia.

Tan, H. A. A. and Alles, L. (1998) "An Examination of Causality and Predictability Between Australian Domestic and Offshore Interest Rate." A paper presented at the NFA/APFA First Joint International Conference. July 19-22, 1988, Tokyo, Japan.

Tang, K.M. and Gannon, G. (1997) "Modelling Volatility in the Malaysian Stockmarket". A paper presented at the 4th Asia Pacific Finance Association Conference, July 14th - 16th, 1997. Kuala Lumpur, Malaysia.

Wang, J.X. and Wong, H.I. (1997). "The predictability of Asian Exchange Rates: Evidence from Kalman Filter and ARCH Estimations". A paper presented at the 4th Asia Pacific Finance Association Conference, July 14th - 16th, 1997. Kuala Lumpur, Malaysia.

West, K.D. and Cho, D. (1995). "The Predictive Ability of Several Models of Exchange Rate Volatility". *Journal of Econometrics,* Vol. 69, Iss. 2, pg. 367-391, Oct. 1995.