Chapter 6

Conditional Correlations among International Gold and ASEAN Emerging Stock Markets

Understanding how conditional correlations between the markets vary overtime is very substantial for constructing portfolio and risk management. Information on the degree of the conditional correlations provides useful guidelines investors in selecting efficient portfolio when investing in ASEAN emerging markets. This chapter examines the interdependencies among the 5 ASEAN emerging stock markets (Indonesia, Malaysia, Philippines, Thailand and Vietnam), and international gold market through estimation of their conditional correlations. Such the motivation, multivariate GARCH models *i.e.*, the CCC-GARCH and DCC-GARCH models are employed to evaluate the conditional correlations between these markets over the sample period.

6.1 Introduction

In finance, it is usually the case that the conditional correlations and covariances between the markets, reflecting their possible interdependencies over time, are the topics of interests. Understanding how conditional correlations between the markets vary overtime is very substantial for constructing portfolio and risk management. Such the motivation, multivariate GARCH models can potentially overcome these deficiencies with their univariate counterparts.

Nowadays, the recent economic crisis is happening over the world, leading to a strong decline in global stock markets. ASEAN emerging stock markets are affected negatively from the crisis. Together with high volatility in the stock markets, the world gold market volatility tends to be high during the recent time, due to the worried psychology of investors about a long economic crisis and high inflation. That is the reason why prices of gold have continuously achieved new high records. However, how correlations among ASEAN emerging stock and gold markets are going on over time, particularly during the recent economic crisis, have not been known. Changes in the conditional correlations between these markets may have significant effects on the portfolio management. To date, no studies have been found that show the conditional correlations among the international gold and ASEAN emerging stock markets.

The purpose of this chapter is to examine the conditional correlations among ASEAN emerging stock and international gold markets, using the constant conditional correlation (CCC) model and the dynamic conditional correlation (DCC) model that are of the most widely employed multivariate GARCH specifications for studying the dynamic conditional correlations. The remaining part of this chapter is

organized as follows: Section 6.2 provides data; Section 6.3 presents model specifications; Section 6.4 reports the empirical results and discussions; and Section 6.5 provides concluding remarks.

6.2 Data

In this chapter, daily closing data of 5 emerging stock markets in ASEAN, namely JKSE, KLSE, PSE, SET and VNI, which represent for the stock exchanges in Indonesia, Malaysia, the Philippines, Thailand and Vietnam, respectively, and daily prices of the PM London Gold Fix (GoldFix) remain in use. The sample period for analysis remains the same as in Chapter 5 (from July 28, 2000 to March 31, 2009).

6.3 Model Specifications

In general, the conditional mean equations of daily returns of the sample markets in MGARCH models can be written as follows,

$$r_{it} = E(r_{it} \mid \Psi_{t-1}) + \varepsilon_{it}, \quad with \quad \varepsilon_{it} \mid \Psi_{t-1} \sim N(\mu_{it}, h_{it}) \tag{6.1}$$

$$\varepsilon_{it} = \sqrt{h_{it}}\, z_{it}, \quad with \quad z_{it} \sim iid(0,1). \tag{6.2}$$

Let $i = 1...s$ be the number of the sample markets, $t = 1...n$ the number of observations, r_{it} return series of the selected markets, $\varepsilon_{it} = r_{it} - \mu_{it}$ the residuals or shocks to market returns, h_{it} the univariate time-varying conditional variances of the selected market returns, $D_{it} = diag(\sqrt{h_{it}})$ a diagonal matrix, Ψ_{t-1} the past information available at time t, $z_{it} = \varepsilon_{it} / \sqrt{h_{it}}$ the standardized residuals to the selected market

returns. In constructing the multivariate conditional variance equations, Bollerslev (1990) introduced the constant conditional correlation (CCC) model. As defined in (6.1) and (6.2), the conditional covariance matrix, H_t , in the CCC model is written as follows

$$H_t = E(\varepsilon_t \varepsilon_t^{'} \mid \Psi_{t-1}) = E(D_t z_t z_t^{'} D_t) = D_t R D_t . \tag{6.3}$$

$R = E(z_t z_t^{'}) = \{\rho_{ik}\}$ be a symmetric positive definite matrix that $\{\rho_{ik}\} = \{\rho_{ki}\}$ with $\rho_{ik}=1 \; \forall \; i=k$ (*for i, k = 1,..., s*). Hence, R is the matrix of the constant conditional correlations, $\{\rho_{ik}\}$, between different pairs of the market returns. In the CCC model, Bollerslev, (1986) assumes that the univariate conditional variance for the return series, h_{it}, follows a univariate GARCH process as

$$h_{it} = \omega_i + \sum_{j=1}^{p} \alpha_{ij} \varepsilon_{i,t-j}^2 + \sum_{j=1}^{q} \beta_{ij} h_{i,t-j} \tag{6.4}$$

Let α_{ij} be the ARCH effects implying the short-run effects of shocks, β_{ij} the GARCH effects or the contribution of such shocks to long-run persistence ($\alpha_{ij} + \beta_{ij}$). Bollerslev (1986) indicated that $\omega_i > 0$, $\alpha_{ij} \geq 0$ for $j= 1,..., p$ and $\beta_{ij} \geq 0$ for $j= 1,..., q$ are sufficient conditions for a positive conditional variance $h_{it} > 0$, and $\sum_{j=1}^{p} \alpha_{ij} + \sum_{j=1}^{q} \beta_{ij} < 1$ is the necessary and sufficient condition for the existence of the second moment. The simplest case is GARCH(1,1) model, *i.e.*, $h_t = \varpi + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1}$, but has been most widely used in practice.

The assumption of the constant conditional correlations in the CCC models may not be hold in reality. To relax this assumption, Engle (2002) proposed the dynamic conditional correlation (DCC) model, which is a generalization of the CCC model. The DCC model can be expressed as follows

$$\varepsilon_t \mid \Psi_{t-1} \sim N(0, H_t) ,$$

$$H_t = D_t R_t D_t \tag{6.5}$$

Let H_t be the conditional covariance matrix, $D_t = diag(\sqrt{h_{it}})$ a diagonal matrix of the univariate conditional variance equations, R_t the a conditional correlation matrix. The conditional variance (h_{it}) in the D_t is assumed to follow a univariate GARCH model as given in (6.4). The DCC estimation of conditional variances and correlations is conducted through two stages. In the first stage univariate volatility parameters in (6.4) are estimated for each return series, using GARCH model and so the standardized shocks, $z_{it} = \varepsilon_{it} / \sqrt{h_{it}}$, are obtained. In the second stage, the standardized residuals, z_{it}, obtained from the first stage are used to estimate the parameters of the dynamic conditional correlations, $q_{ik,t}$. In this chapter, we employ the DCC(1,1) version of Engle (2002), so the model can be written as follows

$$R_t = \{diag(q_{ii,t})^{-1/2}\}\, q_{ik,t}\, \{diag(q_{kk,t})^{-1/2}\} = \{\rho_{ik,t}\}, \text{ for } i, k = 1,..., s;\ t = 1,...,n \tag{6.6}$$

$$q_{ik,t} = (1 - \theta_1 - \theta_2)\overline{\rho}_{ik} + \theta_1 z_{i,t-1} z_{k,t-1} + \theta_2 q_{ik,t-1}, \tag{6.7}$$

Engle (2002) defined that $\bar{\rho}_{ik}$ in (6.7) is the unconditional correlation between $z_{i,t}$ and $z_{k,t}$, obtained from the first stage, and (6.6) is used to standardize the matrix estimated in (6.7). In (6.7), θ_1 and θ_2 are parameters to be estimated. If the estimates of θ_1 and θ_2 are significantly different from zero, then conditional correlation in the whole is not constant. On the contrary, if the estimates of θ_1 and θ_2 are not significant, then $q_{ik,t}$ in (6.7) can be interpreted as the CCC model. The DCC model is estimated using the maximum likelihood estimator (MLE). Engle (2002) showed the log-likelihood function as

$$L = -\frac{1}{2}\sum_{t=1}^{n} s\log(2\pi) + \log|R_t| + z_t' R_t^{-1} z_t \tag{6.8}$$

It is assumed that z_t in (6.8), the standardized residual series obtained from the first stage, $z_t = \varepsilon_t / \sqrt{h_t}$, is normally distriduted with zero mean and variance, R_t.

6.4 Empirical Results and Discussions

Normally, the interaction between two assets or markets is referred as correlation. In this chapter, correlation is a measure used to describe how returns of two markets move in relation to each other over the sample period. Correlation coefficients lie in the [-1, 1] interval, where perfectly negative and positive correlations are -1 and +1, respectively. In this section, we focus on the market level, so MGARCH estimations of the conditional correlations in the sample markets have been implemented to see how closely returns of the pair markets move together, using the CCC and DCC approaches. The DCC model was employed to capture the time-

varying conditional correlations, contrary to the benchmark CCC model which maintains the constant conditional correlations.

The estimates of the constant conditional correlations for the CCC model in the selected market returns are presented in Table 6.1. It indicates that all the estimated correlations are positive. For the 6 six selected markets, there exist 15 pair correlations. The estimated results reveal that these correlations are statistically significant difference from zero in most of the cases, except two market pairs (Vietnam, Malaysia) and (Vietnam, Thailand). Generally, the conditional correlations between the selected market returns are below medium level (<0.4). The highest correlation is found in the market pair (Indonesia, Thailand), while the lowest one is in the case of (gold and Thailand). Especially, gold and Vietnam stock markets display very low correlations (<0.1) with other sample markets in returns. In terms of international investment, it is very crucial to note that portfolio managers, who apply the top-down approach should target their investment allocations in different groups of markets that exhibit low, if not negative, correlations as the rule *i.e.,* market groups (Thailand, Vietnam, gold), (Indonesia, Vietnam, gold), (Malaysia, Vietnam, gold) and (Philippines, Vietnam, gold) as the country level. Picking Indonesia, Malaysia, Thailand and the Philippines markets together could not be wise, since these 4 markets show higher correlations to each other (0.2417 to 0.3846) as compared to the remaining sample pairs. By doing so, investors can reduce total portfolio risk without affecting portfolio return. Perhaps, Vietnam is a new emerging stock market, so it seems to be inconsiderably influenced by the other markets. And, gold plays an important role in hedging risks, especially in the financial crisis period.

Table 6.1: Constant Correlations between the Selected Market Returns in the CCC Model

Market Returns	GOLDFIX	JKSE	KLSE	PSE	SET
JKSE	0.0595				
	(0.001)				
KLSE	0.0661	0.3767			
	(0.005)	(<0.001)			
PSE	0.0648	0.3217	0.3231		
	0.005	(<0.001)	(<0.001)		
SET	0.0208	0.3846	0.3627	0.2417	
	(0.354)	(<0.001)	(<0.001)	(<0.001)	
VNI	0.0364	0.0427	0.0320	0.0923	0.0264
	(0.097)	(0.093)	(0.200)	(<0.001)	(0.289)

Notes: The figures in parentheses are the p-values.

The estimates of the DCC parameters for the dynamic conditional correlations in the sample markets, based on estimating univariate GARCH(1,1) models for each return series, are reported in Table 6.2. It indicates that the DCC parameters, θ_1 and θ_2 are positive and significant different from zero, which make clear that the assumption of the constant conditional correlations between the sample market returns is not supported empirically, so the conditional correlations in the whole are time varying. Moreover, the short run persistence of shocks to the dynamic conditional correlations is very small at 0.0089, while sum of the DCC parameters is high at 0.9831 and is close to one implying that in the long run, effects of shocks to the conditional correlations is highly persistent.

Table 6.2: Estimates of the DCC Parameters for the Selected Market Returns

DCC parameters	Estimates
θ_1	0.0089
	(<0.001)
θ_2	0.9742
	(<0.001)
$\theta_1 + \theta_2$	0.9831

Notes: The figures in parentheses are the p-values.

Table 6.3 shows a descriptive statistics of the time varying conditional correlations, obtained from the DCC model. Generally, the sample means of the time varying conditional correlations in all the 15 market pairs exhibit low to medium interdependence over time. However, they lie in a wider range [-0.0093, 0.4224] as compared to the range [0.0208, 0.3846] of the constant conditional correlations given in Table 6.3. On average, the time varying conditional correlations between the gold and 5 stock markets estimated in the DCC model are lower than those estimated in the CCC model, whereas the time varying conditional correlations in the 10 pairs between the 5 stock markets (Indonesia, Malaysia, Philippines, Thailand and Vietnam) estimated in the DCC model are all higher than those estimated in the CCC model.

Table 6.3: Descriptive Statistics of the Estimated Dynamic Conditional Correlations in the Market Pairs

	Mean	Maximum	Minimum	St.dev.	Skewness	Kurtosis	C.V
GOLDFIX, JKSE	0.0450	0.1993	-0.1706	0.0553	0.2997	3.09	122.87
GOLDFIX, KLSE	0.0518	0.2044	-0.1712	0.0470	0.4595	4.08	90.68
GOLDFIX, PSE	0.0545	0.2082	-0.2003	0.0466	-0.3938	5.55	85.49
GOLDFIX, SET	-0.0093	0.1195	-0.3331	0.0561	-1.5444	8.68	-601.48
GOLDFIX, VNI	0.0132	0.1110	-0.1180	0.0292	0.1619	4.58	221.30
JKSE, KLSE	0.4224	0.6420	0.2540	0.0642	1.1627	4.60	15.20
JKSE, PSE	0.3475	0.5172	0.2211	0.0529	0.6664	4.05	15.22
JKSE, SET	0.4164	0.5939	0.2547	0.0557	0.2329	2.81	13.37
JKSE, VNI	0.0734	0.2948	-0.0345	0.0443	1.7501	8.12	60.29
KLSE, PSE	0.3565	0.5876	0.1638	0.0614	0.7621	4.89	17.23
KLSE, SET	0.3899	0.6313	0.2251	0.0582	0.6438	5.45	14.93
KLSE, VNI	0.0681	0.2893	-0.0419	0.0416	2.2443	10.50	61.09
PSE, SET	0.2617	0.5694	0.1422	0.0551	1.8773	9.38	21.06
PSE, VNI	0.1284	0.4441	0.0234	0.0572	2.7886	12.57	44.54
SET, VNI	0.0676	0.2982	-0.0836	0.0464	1.4820	8.11	68.68

The DCC model indicates a more important role of gold as a diversified asset in the portfolios and a lesser attractiveness of the Vietnam stock market in hedging strategies than the CCC model over the sample period. Through the sample means of the time varying conditional correlations given in Table 6.3, we find that, on average, the gold and Vietnam stock markets express very low to negative correlations with the other sample markets (-0.0093 to 0.1284) over time, while the 4 remaining stock markets (Indonesia, Malaysia, Philippines and Thailand) exhibit relatively low to medium correlations with each other (0.2617 to 0.4224). These findings are consistent with the findings in the CCC model.

The last column in Table 6.3 provides the coefficients of variation (C.V), defined as the ratio of the standard deviation to the mean, in the dynamic conditional correlations through the 15 market pairs over the sample period. Actually, the dynamic conditional correlations in a market pair with the smaller C.V are less dispersed from the mean than those in other pair with the larger C.V. The highest C.V is found in the market pair (Gold, Thailand), while the lowest one is the case (Indonesia, Thailand). Overall, high C.V in the dynamic conditional correlations are found between gold and the 5 stock markets (85.5% to 601.5% in absolute value), while the medium cases (44.5% to 68.7%) occur in the market pairs between Vietnam and the other 4 stock markets, and the low ones (13.4% to 21.1%) exist in the remaining pairs. The skewness and kurtosis of the dynamic conditional correlations indicate a positively skewed distribution in most cases.

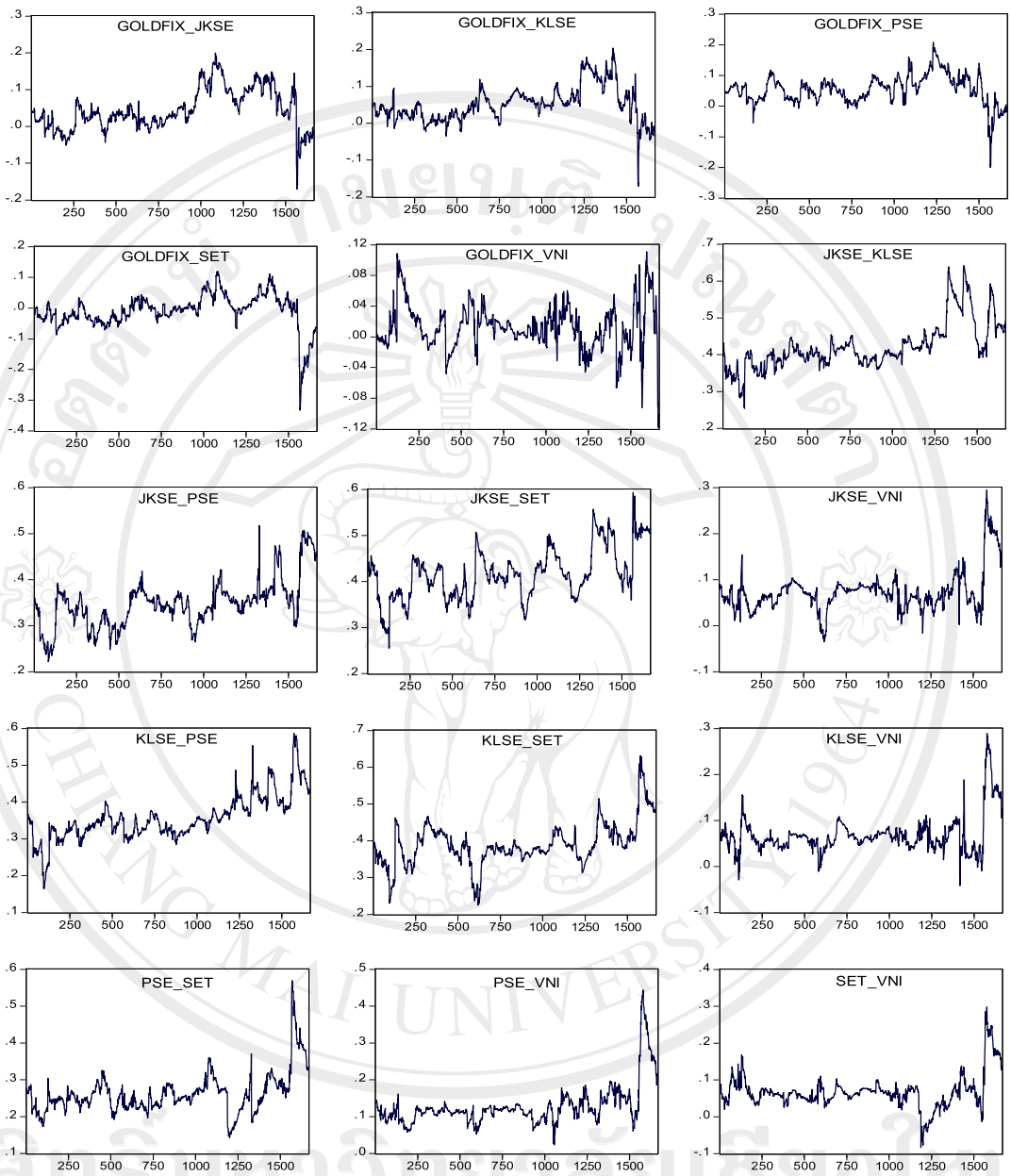

Figure 6.1: Dynamic Paths of the Estimated Conditional Correlations between the Sample Market Return Pairs

The dynamic paths of the conditional correlations in the 15 pairs of the sample market returns obtained from the DCC model are plotted in Figure 6.1. The plots of the pair correlation series illustrate a varying pattern in the correlation dynamic paths, so the constant conditional correlations appear to be refuted as considerable variations

occur in all the pairs over the sample period. Especially, large variations in the conditional correlations can be seen in all the pairs over the last part of the time path, which denotes the recent financial and economic crisis. Slightly upward trend in the conditional correlations appears in the market pairs (Malaysia, Indonesia), (Malaysia, Philippines), (Malaysia, Thailand), (Indonesia, Philippines), (Indonesia, Thailand) and (Philippines, Thailand) over the sample period, which reveals increasing interdependencies over time. Meanwhile, no clear trend seems to be observed in the plots of the remaining market pairs that consist of gold and/or Vietnam, over the sample period. However, during the last part of the time path, the pattern of correlations tends to change, as the sharp downward trend from low to negative levels occurs in the 5 pair correlations between the gold and 5 ASEAN emerging stock markets, whereas the rapid upward trend appears in the 4 pair correlations between Vietnam and the 4 remaining stock markets, meaning that the Vietnam stock market could be more integrated with the other ASEAN emerging stock markets. Interestingly, these behaviors of the conditional correlations change suddenly in the end period of the time path and then they are adjusted gradually. This could be due to the adjusted behavior of investors in restructuring the portfolio during the recent financial crisis.

6.5 Concluding Remarks

The paper provides an insight on the interdependencies among ASEAN emerging stock and international gold markets through examining the conditional correlations between them. Multivariate GARCH models *i.e.,* the CCC model of

Bollerslev (1990) and the DCC models of Engle (2002) were applied to see how closely returns of each market pair move together.

The estimates of the CCC and DCC models, in general, exhibit medium to low interdependencies between the sample markets. Typically, the gold and Vietnam stock markets display very low to negative correlations with the remaining sample markets over time. While, the Indonesia, Malaysia, Philippines and Thailand stock markets show medium correlations with each other. As the rule of investment, portfolio managers should target their allocations in groups of markets that reveal low correlations to reduce total portfolio risk without affecting portfolio return.

The estimates of the DCC model show a varying pattern in all the pair correlation dynamic paths over the sample period. The interdependencies among the Indonesia, Malaysia, Philippines and Thailand stock markets are growing over time. Moreover, during the recent financial crisis, the downward trend in the correlations between gold and ASEAN emerging stock markets highlights more attractiveness of gold as a diversified asset in the portfolios. Meanwhile, the Vietnam stock market tends to be more correlated with other ASEAN markets, so this may reduce its attractiveness in hedging risks when investing in ASEAN markets.