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GOLD HEDGING STRATEGIES IN THE ASIAN MARKETS

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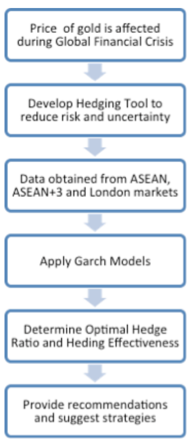
Graphical abstract



Abstract

During 2007, the gold price was declining due to effect from Global Financial Crisis. After this period, gold price suffered significant drop due to low inflation among countries.Hedging is a tool to mitigate risk and uncertainty in gold prices. This research analyzed the relationship between gold spot and futures prices in the Asian markets (Singapore, Thailand, Indonesia, Malaysia, Tokyo, Korea, Shanghai and Hong Kong) and London market. This study also investigated the ability of gold futures as a hedging tool to gold spot during financial market stress. The investigation employed multivariate GARCH and OLS models for optimal hedge ratio estimation of gold futures. Sample data consists of daily gold spot and futures prices denoted in US dollars per troy ounces. There are four sub–periods (Period I, Period II, Period III and Period IV) considered which covers from 2nd February 2009 until 31st October 2014 of 1500 observations. Using Diagonal BEKK model, it can be suggested that one dollar long (buy)in gold spot should be shorted (sold) by about 78.26 cents of Thailand gold futures during the crisis period and Thailand futures market of 74.85 cents for the post crisis period. It can be argued that hedging effectiveness is higher during global financial crisis as compared to post global financial crisis. It is observed that Diagonal BEKK outperformed minimum variance, CCC and DCC models.

Keywords: Asian markets, gold futures, hedging effectiveness, hedge ratio, garch.

1.0 INTRODUCTION

Gold mining activities have contributed significantly to the international markets over the past four decades. Currently, there are 90 countries involved in the mining of gold with the total production of 2,700 tons of gold (2012 estimates) and China is the leader in the gold production for the past seven years. The theory and practice of hedging are more developed in recent years due to the increasing role of derivative markets. Mining companies utilize these hedging tools to overcome the risk and uncertainty due to price fluctuations. It is also found that the price of gold is affected by movements in oil price and inflation.

Early research employed constant hedging model which is estimated using Ordinary Least Squares (OLS) method. Nevertheless, constant models are criticized due to constant variance and covariance between spot and futures returns over time. Despite, recent studies [11] have found that OLS approach is the best model in estimating optimal hedge ratio. However, if the distributions of spot and futures prices are changing through time, then a constant hedge ratio may not be appropriate [10]. In order to estimate hedging portfolios which change through time, [10] used a multivariate GARCH model to account for the changing distributions in asset prices.

The objectives of this study are to analyze the relationship between gold spot and futures prices in the Asian markets and London market, to examine the ability of gold futures as a hedging tool to gold spot for Asian markets and to calculate and evaluate the hedging effectiveness of gold futures as a hedging tool to gold spot. Considerably, this study would help in understanding the relationship of gold spot and futures prices. Besides, this study will facilitate mining companies and other investors to develop better hedging strategies based on hedging performance of different gold markets.

2.0 LITERATURE REVIEW

[12] Interested in the relationship of gold price and other economic variables such as crude oil price and inflation. The relationship between gold prices and oil prices for the last forty years is high with correlation of 85 percent. On the other hand, the relationship between gold prices and inflation is low and negative with a correlation coefficient of -9 percent.

[1] Examined the role of gold as a safe haven in the global financial system. Using 30 year period data (from 1979 to 2009), [1] found that gold can be used as a hedge and a safe haven for major European stock markets. In addition, the study proved that gold was not affected by high price movements in other assets and thus gold can act as stabilizing tool in diversification strategy. Hence, study on gold market is very useful for traders and market players to eliminate risk exposure of stocks and commodities prices fluctuations.

Futures market is a liquid market in the world and it is traded on an organized exchange. Futures market has been used by speculators, arbitrageurs, policymakers and producers to minimize risk by anticipating the spot prices in the future. Hedgers use derivative securities to reduce the risk from variations in the spot market. The hedge ratio is defined as the ratio of the size of futures contracts to the size of the total exposure. In other words, the hedge ratio provides information on the amount of futures contract to be held. The hedging effectiveness determines the percentage of variance of unhedged returns that can be reduced through hedging. The purpose of hedging is to combine investments in the spot market and futures market in such a way to reduce the risk of price fluctuations. Optimal hedge ratio is defined by the hedge ratio that minimizes conditional variance and covariance of hedged portfolio and maximizes expected utility.

In the earlier literature, the common assumption is that, the parameter of the hedge ratio is constant and non-dynamic. The other underlying reasons for the hedge ratio to be varied with respect to time might be technological evolution, economic or financial crisis. Also, there may be variations in the behavior and perception of the people, changes in policy and structure of the organization. In the early years, OLS based method has been explored by [6] and [9]. However, it has been proved that a constant hedge ratio may be inappropriate when prices are non-stationary. [5] Suggested that conditional variance-covariance time-varying hedge ratio should be used to incorporate non-stationarity of financial time series. There are now substantial evidences that financial market volatility is both time-varying and highly predictable.

Furthermore, [11] observed hedging effectiveness of futures contract on financial assets and commodities in Indian markets specifically, daily closing prices S&P CNX Nifty index and its futures contract, gold futures contract and soybean futures contract. The study compared the performance of models and estimated dynamic hedge ratios using VAR-Multivariate GARCH and constant hedge ratios using OLS, VAR and VECM. VAR-Multivariate GARCH performed better than other models. Results also showed that futures and spots prices are co-integrated in the long run. Likewise, [10] used multivariate GARCH models for weekly US dollar (USD) per Japanese Yen (JPY) exchange rate was used for spot and futures from May 7, 1980 to August 12, 1987. Results showed that time-varying hedge ratio outperformed the constant hedge ratio.

3.0 METHODOLOGY

This study explores GARCH (Generalized Autoregressive Conditional Heteroscedasticity) models to estimate the optimal time varying hedge ratios in spot and futures gold in the Asian markets. Due to London as a home to international benchmark price for gold, London markets for gold was also considered. Thailand Futures Exchange launched gold futures in February 2009. Singapore Mercantile Exchange and Korea Futures Exchange came into play in May 2010. Meanwhile in Malaysia, the gold future was introduced in October 2013. The increasing trend of gold futures introduction by market- and country-based is to remove the need for local participants to purchase foreign currency, remove arising foreign currency fluctuations and reduce contract entry costs.

The earliest establishment in Asian was Tokyo Commodity Exchange (TOCOM) which introduced gold futures in March 1982 followed by Shanghai Futures Exchange and Hong Kong Futures Exchange in January 2008 and October 2008 respectively. Indonesia Commodity Exchange is the latest participant in gold futures market which launched the product in May 2014. Therefore, Thailand, Singapore, Korea, Bursa Malaysia and Indonesia have limited historical data to be analyzed compare to other pioneer market players. This study assumes that gold prices are expressed in US dollars per troy ounces for all 9 gold futures markets.

This study split the sample data into four sub–periods (Period I, II, III and IV). Period I is between 2nd February 2009 and 31st July 2009. There are 130 daily observations of gold spot and futures markets. The markets involved were London, Tokyo, Shanghai, Hong Kong and Thailand markets. Period I represents the time during global financial crisis. Moving on to Period II, the time frame was set from 3rd August 2009 to 10th September 2010. This period represents the time after global financial crisis. 290 samples of daily observations were identified for the five markets identical from Period I.

Period III has the time frame from 13th September 2010 to 1st May 2014. This period consists of 949 daily observations of gold spot and futures prices. It includes Singapore and Korea in addition to previous five markets. Lastly, Period IV combines all seven markets from previous periods (Period I, II, and III). Bursa Malaysia and Indonesia markets were added due to recent introduction and the data is taken from 2nd May 2014 to 31st October 2014 of 131 daily samples.

3.1 Hedging Strategy Models

The minimum variance hedge ratio and the futures hedge position that minimizes the conditional variance of the portfolio returns is the optimal hedge ratio. Based on study by [14], consider that an investor hold a long position in gold spot and a short position in gold futures contract. Hedge ratio denoted by φ is the number of short futures contracts.Logarithms of spot and futures gold prices a time *t* are denoted as S_t and F_t and returns are defined as changes in logarithms of prices. Returns on spot and futures gold positions are given by $R_{s,t} = ln(S_t / S_{t-1})$ and $R_{f,t} = ln(F_t / F_{t-1})$ and return on portfolio is $R_{p,t} = R_{s,t} - \varphi R_{f,t}$.

By conditioning information at *t-1*, the expected portfolio return and the conditional portfolio variance can be written as:

$E(R_{p,t} \mid \Omega_{t-1}) = E(R_{s,t} \mid \Omega_{t-1}) - \varphi_{t-1} E(R_{f,t} \mid \Omega_{t-1})$

and

$Var(R_{p,t} \mid \Omega_{t-1}) = Var(R_{s,t} \mid \Omega_{t-1}) - 2\varphi_t\, Cov(R_{s,t}, R_{f,t} \mid \Omega_{t-1}) + \varphi_t^2 Var(R_{f,t} \mid \Omega_{t-1})$

where Ω_{t-1} is the information available from the past. According to the first order condition, minimize $Var(R_{p,t} \mid \Omega_{t-1})$ to obtain the optimal hedge ratio:

$\frac{\delta(Var\,(R_{p,t}|\Omega_{t-1}))}{\delta(\varphi_t|\Omega_{t-1})} = 2\varphi_t\, Var(R_{f,t} \mid \Omega_{t-1}) - 2\, Cov(R_{s,t}, R_{f,t} \mid \Omega_{t-1}) = 0$

The futures hedge position that minimizes the conditional variance of the portfolio returns in Equation (2) is the estimated optimal hedge ratio and is given by:

$\varphi^*_t \mid \Omega_{t-1} = \frac{Cov(R_{s,t},R_{f,t}|\Omega_{t-1})}{Var(R_{f,t}|\Omega_{t-1})}$

GARCH (1, 1) modelled by [3]is adopted in this study in order to take care for the heteroscedasticity in the model. In this paper, constant conditional correlation (CCC) specification by [3], dynamic conditional correlation (DCC) by [7]and Baba, Engle, Kraft and Kroner (BEKK) GARCH are considered.

3.2 Econometric Modeling

The GARCH (*p*, *q*) process is then given by:

$\varepsilon_t \mid \varphi_{t-1} \sim N(0, h_t)$,

$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i h_{t-i}^2 = \alpha_0 + A(L)\varepsilon_t^2 + B(L)h_t^2$,

where $p \geq 0$, $q \geq 0$, $\alpha_0 \geq 0$, $\alpha_i \geq 0$, $i = 1, \ldots, q$ and

$\beta_i \geq 0$, $i = 1, \ldots, p$.

For $p = 0$, the process reduces to ARCH (*q*) process and for $p = q = 0$, ε_t is simply white noise. A stochastic process purely random or white noise if it has zero mean, constant variance and serial uncorrelated error term. In ARCH (*q*) process, the conditional variance is specified as a linear fuction of past sample variances only, whereas the GARCH (*p*, *q*) process allows lagged conditional variances to enter as well [2].

The Constant Conditional Correlation (CCC) GARCH model was introduced by [2] that the conditional correlation is constant while the conditional variances are varying and the estimation is given by:

$y_t = E(y_t \mid I_{t-1}) + \varepsilon_t, \qquad \varepsilon_t = D_t\eta_t,\ var(\varepsilon_t \mid I_{t-1}) = D_t\Gamma D_t$

where $y_t = E(y_{1t}, \ldots, y_{mt})'$, $\eta_t = (\eta_{1t}, \ldots, \eta_{mt})'$ is a series of independently and identically distributed (iid) random vectors. I_t is the past information at time *t*, $D_t = diag\,(h_1^{\frac{1}{2}}, \ldots, h_m^{\frac{1}{2}})$, the constant conditional correlation matrix of the unconditional shocks, η_t, is equivalent to the constant conditional covariance matrix of the conditional shocks, ε_t from Equation (8), $\varepsilon_t\varepsilon_t' = D_t\eta_t\eta'_tD_t, D_t = (diag\, Q_t)^{1/2}$, and $E(\varepsilon_t\varepsilon'_t|F_{t-1}) = Q_t = D_t\Gamma D_t$, where Q_t is the conditional covariance matrix. The conditional covariance matrix is positive definite if and only if all the conditional variances are positive and Γ is positive definite. This model assumes the conditional variance for each return, $h_{it}, i = 1, \ldots, m$, follows a univariate GARCH process and given by:

$$H_{it} = \omega_i + \sum_{j=1}^{r} \alpha_{ij}\varepsilon_{i,t-j}^2 + \sum_{j=1}^{s} \beta_{ij}H_{i,t-j}$$

where α_{ij} represents the ARCH effect, or short run persistence of shocks to return i, β_{ij} represents the GARCH effect, and $\sum_{j=1}^{r}\alpha_{ij} + \sum_{j=1}^{s}\beta_{ij}$ denotes the long run persistence. The number of parameters to be estimated reduces to $\left(\frac{n(n-1)}{2}\right) + n(1 + q + p)$.

The Dynamic Conditional Correlation model was proposed by [7]. It is a generalized version of the CCC model and it is a nonlinear combination of univariate GARCH models. Consider the gold spot returns and futures returns are estimated in a bivariate model as per below:

$R_{s,t} = \mu_s + \lambda_s B_{t-1} + \varepsilon_{s,t}$ and

$R_{s,t} = \mu_f + \lambda_f B_{t-1} + \varepsilon_{s,t}$ and

where μ_s and μ_f are intercepts, $B_{t-1} = F_{t-1} - S_{t-1}$ is the lagged basis, and $\varepsilon_{s,t}$ and $\varepsilon_{f,t}$ are error terms. B_{t-1} is the long run error correction term. This is due to the possibility of co integration relationship between spot and futures prices and employed in estimating optimal hedge ratios by [4]. The vector residuals form is $\varepsilon_t = [\varepsilon_{s,t}\varepsilon_{f,t}]'$. The conditional distribution of ε_t is assumed to be bivariate normal with the conditional variance-covariance matrix is given as:

$H_t = Var(\varepsilon_t \mid \Omega_{t-1}) = \begin{bmatrix} h_{s,t} & \rho_t\sqrt{h_{s,t}h_{f,t}} \\ \rho_t\sqrt{h_{s,t}h_{f,t}} & h_{f,t} \end{bmatrix}$

where $h_{s,t} = Var(R_{s,t} \mid \Omega_{t-1})$, $h_{f,t} = Var(R_{f,t} \mid \Omega_{t-1})$ and ρ_t are the conditional correlation coefficient between spot and futures returns. Using this specification of the conditional variance-covariance matrix, the optimal hedge ratio becomes

$$\varphi^*_{t-1} = \rho_t \sqrt{\frac{h_{s,t}}{h_{f,t}}}.$$

With respect to DCC GARCH model [7]and CCC GARCH model [3], the conditional variance equations are written as:

$$h_{s,t} = \omega_s + \alpha_s \varepsilon^2_{s,t-1} + \beta_s h_{s,t-1};$$
$$h_{f,t}=\omega_f+\alpha_f \varepsilon^2_{f,t-1}+\beta_f h_{f,t-1}.$$

Therefore, DCC specification, the conditional correlation coefficient is modeled as:

$$\rho_t = (1 - \phi_1 - \phi_2)\bar{\rho} + \phi_1 \rho_{t-1} + \phi_2 \pi_{t-1}$$

where $\bar{\rho}$ is the unconditional correlation between $\varepsilon_{s,t}$ and $\varepsilon_{f,t}$, and:

$$\pi_{t-1} = \frac{\sum_{h=1}^{m} \eta_{s,t-h}\, \eta_{f,t-h}}{\sqrt{\sum_{h=1}^{m} \eta_{s,t-h}^2 \ \sum_{h=1}^{m} \eta_{f,t-h}^2}}$$ for $m \geq 2$, where $\eta_{s,t-j} = \frac{\varepsilon_{s,t}}{\sqrt{h_{s,t}}}$ and $\eta_{f,t-j} = \frac{\varepsilon_{f,t}}{\sqrt{h_{f,t}}}$.

BEKK is a dynamic conditional model that has positive definite on the conditional covariance matrices. Defining $N \times N$ matrices, A_j and B_i and an upper triangular matrix C_0, the BEKK model for multivariate GARCH (1, 1) is as follows:

$$H_t = C_0 C_0' + \sum_{j=1}^{q} A_j\, \varepsilon_{t-j}\, \varepsilon_{t-j}' A_j' + \sum_{i=1}^{p} B_i\, H_{t-i}\, B_i'$$

The decomposition of the constant term into a product of two triangular matrices is to ensure the positive definiteness of variance covariance matrix, H_t. Diag – BEKK (p, q) involved the highly simplified version of Equation (17) when both A and B are assumed to be diagonal matrices [3].

3.4 Hedging Effectiveness

Hedging performance metric is as per below:

$$HP = \left(1 - \frac{\sigma_{HE}^2}{\sigma_R^2}\right),$$

where σ_R^2 is the variance of the unhedged gold spot returns. This measures the variance reduction achieved by using the futures contract relative the original unhedged gold spot variance.

4.0 RESULT AND DISCUSSION

4.1 Data Statistics

Table 1 presents the summary statistics for gold spot and futures returns. Observed Period I (Hong Kong, Tokyo, London, Shanghai and Thailand markets), standard deviation for Period I is from 0.0104 percent to 0.0146 percent implies low volatility. Hong Kong (skewness= -0.2090) and Thailand (skewness= -0.4922) markets have negative skewness while Tokyo, London, Shanghai and spot markets have positive skewness. Negative skewness implies that return of gold price has a long left tail for its distribution. The kurtosis returns for all markets of gold prices are highly peaked (more than 3)indicated that the returns series have leptokurtosis. Move on to Period II (Hong Kong, Tokyo, London, Shanghai, Thailand and spot markets), standard deviation is from 0.0099 percent to 0.0123 percent (low volatility). Hong Kong, Tokyo, London, Shanghai, Thailand and spot markets have negative skewness and the kurtosis returns of gold prices are peaked (more than 3).

As for Period III (Hong Kong, Tokyo, London, Shanghai, Thailand, Korea, Singapore and spot markets), standard deviation is from 0.0113 percent to 0.0124 percent (low volatility). Hong Kong, Tokyo, London, Shanghai, Thailand, Korea, Singapore and spot markets have negative skewness and the kurtosis returns of gold prices are highly peaked (more than 3). For Period IV (Hong Kong, Tokyo, London, Shanghai, Thailand, Korea, Singapore, Bursa Malaysia, Indonesia and spot markets), standard deviation is from 0.0070 percent to 0.0081 percent (low volatility). Hong Kong, Tokyo, London, Shanghai, Thailand, Korea, Singapore, Bursa Malaysia, Indonesia and spot markets have negative skewness and the kurtosis returns of gold prices are highly peaked (more than 3). Based on Jarque-Bera, all markets returns are not normally distributed for all periods except for Tokyo in Period I.

4.2 CCC GARCH Results

Table 2 presents the estimation results of CCC GARCH. GARCH estimates of conditional variance are significant and positive. However, the ARCH estimates and some of the parameters of conditional variance are not significant. The ARCH effect estimates (α) are generally small (less than 0.1). However, the GARCH effect estimates (β) are generally high. The GARCH effect (degree of long run persistence) varies across countries. Period I shows that Gold spot (β = 0.932907) is more sensitive to the news and Shanghai gold (β = 0.694148) is less sensitive to the news. Period II shows that Thailand gold (β = 0.911250) is less sensitive to the news and Shanghai gold (β = 0.964425) is more sensitive to the news. Period III shows that Gold spot (β = 0.924055) is more sensitive to the news and Singapore gold (β = 0.808123) is less sensitive to the news.

The CCC estimates between the volatility of gold spot and futures returns for all markets are average, ranging from 0.264866 to 0.880770. The volatility persistence is the sum of α and β. All periods observed that both gold spot and futures market are highly volatile, ranging from 0.748260 to 0.994530. This indicates that gold spot and futures markets in Asian region have long memory process[8].In conclusion, Shanghai(with $\alpha + \beta = 0.748260$ for Period I), Thailand(with $\alpha + \beta = 0.9945$ for Period II) and

Singapore(with $\alpha + \beta = 0.88764$ for Period III)markets have the least sensitive to the news. Besides, London market is sensitive to the news during the period of global financial crisis (variance=0.729) and less sensitive to the news after the period of global financial crisis (variance=0.7076).

4.3 DCCC GARCH Results

Table 3 presents the estimation results of DCC GARCH. In Period I, φ_1 (short run persistence of shocks) is significant for London, Hong Kong, Shanghai and Thailand futures (φ_1 = 0.187326, φ_1 = 0.000000, φ_1 = 0.161436 and φ_1 = 0.117611 respectively). While φ_2 (long run persistence of shocks) is significant for London, Thailand and Tokyo futures (φ_2 = 0.774420, φ_2 = 0.793815 and φ_2 = 0.852910 respectively). In Period II, φ_1 is significant for London, Hong Kong, Thailand and Tokyo futures and φ_2 is significant for London, Hong Kong and Thailand whereas, in Period III, φ_1 is significant for London, Hong Kong, Shanghai, Thailand, Korea and Singapore markets and φ_2 is significant for Shanghai, Korea and Singapore markets only. Period IV is not applicable for CCC and DCC GARCH due to absence of ARCH effect in the time series data. It can be argued that during the global financial crisis (Period I) and immediate post global financial crisis (Period II), London futures market has significant φ_1 and φ_2. Thus, it can be concluded that, London futures market has short run and long run persistence of shocks. Similarly,after the global financial crisis (Period III) Shanghai, Korea and Singapore futures markets have significant φ_1 and $\varphi_2$indicating that these futures markets have short run and long run persistence of shocks.

4.4 Diagonal BEKK GARCH Results

The coefficient of ARCH and GARCH are positive definite for Diagonal BEKK GARCH. Diagonal BEKK GARCH ensures conditional variances to be positive that guarantees the resulting conditional covariance matrices to be positive definite. Thus, Diagonal BEKK GARCH is applicable to Period IV. Table 5 shows that there are short run and long run persistence of shocks for London spot and futures markets for Period I, London spot, London futures, Hong Kong and Thailand markets for Period II, London spot, Hong Kong, Thailand, Tokyo and Korea markets for Period III and Tokyo market for Period IV. It can be argued that London spot and futures markets have short run and long run persistence of shocks during crisis (Period I) and immediate post crisis (Period II). However, Hong Kong and Thailand markets have short run and long run persistence of shocks after crisis (Period II and III). Whereas, Tokyo market has short run and long run persistence of shocks in later period of post crisis (Period IV).

Table 1 Descriptive statistics of gold spot and futures daily return series

Pd.	Statistics	Hong Kong	Tokyo	London	Shanghai	Thailand	Korea	Singapore	Bursa M'sia	Indonesia	Gold Spot *
I	Mean	0.0002	0.0003	0.0002	0.0002	0.0003	-	-	-	-	0.0002
	Std. Dev.	0.0123	0.0132	0.0142	0.0146	0.0104	-	-	-	-	0.0141
	Skewness	-0.2090	0.0394	0.5159	0.3413	-0.4922	-	-	-	-	0.5265
	Kurtosis	4.0923	3.8966	6.6772	6.6023	4.8626	-	-	-	-	7.0819
	Jarque-Bera	7.3520	4.3540	78.4021	72.2517	23.8565	-	-	-	-	95.5165
	Prob.	0.0253	0.1134	0.0000	0.0000	0.0000	-	-	-	-	0.0000
II	Mean	0.0009	0.0009	0.0009	0.0009	0.0009	-	-	-	-	0.0009
	Std. Dev.	0.0108	0.0123	0.0103	0.0129	0.0099	-	-	-	-	0.0103
	Skewness	-0.7381	-0.3064	-0.4482	-0.1472	-0.6104	-	-	-	-	-0.1664
	Kurtosis	6.3587	3.8018	4.5157	5.7729	5.8726	-	-	-	-	4.0449
	Jarque-Bera	162.0786	12.2633	37.34	93.6291	117.3095	-	-	-	-	14.4802
	Prob.	0.0000	0.0022	0.0000	0.0000	0.0000	-	-	-	-	0.0007
III	Mean	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-	-	0.0000
	Std. Dev.	0.0113	0.0123	0.0118	0.0124	0.0119	0.0124	0.0121	-	-	0.0119
	Skewness	-1.0343	-1.6169	-1.1639	-0.1516	-1.5774	-2.0755	-0.8102	-	-	-0.8524
	Kurtosis	11.6461	16.2376	11.1814	7.2788	17.864	25.1866	11.702	-	-	9.9236
	Jarque-Bera	3,121.82	7,334.78	2,858.00	726.8159	9,120.18	20,124.33	3,094.86	-	-	2,008.25
	Prob.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-	-	0.0000
IV	Mean	-0.0007	-0.0007	-0.0009	-0.0004	-0.0007	-0.0006	-0.0008	-0.0005	-0.0007	-0.0007
	Std. Dev.	0.0073	0.007	0.0072	0.0081	0.0073	0.0077	0.0076	0.0073	0.0070	0.0074
	Skewness	-0.0453	-0.6061	-0.5574	-0.1011	-0.1095	-0.0691	-0.017	-0.3737	-0.6061	-0.4891
	Kurtosis	4.0863	5.2165	5.2994	5.1819	4.3399	5.6037	6.2215	3.9323	5.2165	5.4147

Jarque-Bera	6.4367	34.5705	35.3695	26.0085	9.9849	36.8256	56.2192	7.7345	34.5705	36.766
Prob.	0.0400	0.0000	0.0000	0.0000	0.0068	0.0000	0.0000	0.0209	0.0000	0.0000

Table 2 The constant conditional correlation garch results

Period	Period I					
Returns	**Spot**	**Futures (London)**	**Futures (Hong Kong)**	**Futures (Shanghai)**	**Futures (Thailand)**	**Futures (Tokyo)**
C	0.000448	0.000400	0.000186	0.000415	-	-
ω	0.006240	0.023254	0.052606	0.546583	-	-
α	0.057345	0.073912	0.070273	0.054078	-	-
β	0.932907[a]	0.908575[a]	0.889494[a]	0.694184[a]	-	-
α + β	0.990250	0.982490	0.959770	0.748260	-	-
CCC		0.729774[a]	0.576037[a]	0.040529	0.507121[a]	0.350565[a]
AIC		-12.422	-12.234	-11.635	-12.502	-11.803
SIC		-12.200	-12.012	-11.413	-12.280	-11.581

Period	Period II					
Returns	**Spot**	**Futures (London)**	**Futures (Hong Kong)**	**Futures (Shanghai)**	**Futures (Thailand)**	**Futures (Tokyo)**
C	0.000969[c]	0.000981[c]	0.000903	0.000863	0.001052[b]	0.000945
ω	0.030662	0.014029	0.035228	0.006112	1.985257	0.057794
α	0.032955	0.039004	0.030387	0.030108[c]	0.071422[b]	0.005480
β	0.938248[a]	0.947788[a]	0.939765[a]	0.964425[a]	0.911250[a]	0.955605[a]
α + β	0.971200	0.986790	0.970150	0.994530	0.982670	0.961090
CCC		0.706150[a]	0.673187[a]	0.380227[a]	0.646118[a]	0.495565[a]
AIC		-13.344	-13.195	-12.470	-13.402	-12.567
SIC		-13.218	-13.068	-12.344	-13.275	-12.440

Period	Period III							
Returns	**Spot**	**Futures (London)**	**Futures (Hong Kong)**	**Futures (Shanghai)**	**Futures (Thailand)**	**Futures (Tokyo)**	**Futures (Korea)**	**Futures (Singapore)**
C	0.000192	0.000176	0.000273	-0.000149	0.000265	0.000069	0.000112	0.000304
ω	0.046388	0.060050	0.061150	0.047242	0.053115	0.034350	0.112326	0.166117
α	0.044718	0.085027	0.095452	0.065637[c]	0.072999[c]	0.070138[a]	0.125605	0.079521
β	0.924055[a]	0.876276[a]	0.863875[a]	0.903481[a]	0.893837[a]	0.911745[a]	0.816992[a]	0.808123[a]
α + β	0.968770	0.961300	0.959330	0.969120	0.966840	0.981880	0.942600	0.887640
CCC		0.880770[a]	0.571082[a]	0.264866[a]	0.539126[a]	0.491570[a]	0.386307[a]	0.678770[a]
AIC		-14.063	-13.031	-12.563	-13.036	-12.719	-12.676	-13.226
SIC		-14.012	-12.979	-12.512	-12.985	-12.668	-12.624	-13.175

[a] is 1 percent significant level [b] is 5 percent significant level [c] is 10 percent significant level

Table 3 The dynamic conditional correlation garch results

Period	Period I						
Returns	Futures (London)	Futures (Hong Kong)	Futures (Shanghai)	Futures (Thailand)	Futures (Tokyo)		
φ_1	0.187326[a]	0.000000[a]	0.161436[c]	0.117611[c]	0.000000		
φ_2	0.774420[a]	0.895191	0.000000	0.793815[a]	0.852910[a]		
AIC	-12.776	-12.203	-11.619	-12.509	-11.772		
SIC	-12.510	-11.937	-11.353	-12.243	-11.506		
Period	**Period II**						
Returns	Futures (London)	Futures (Hong Kong)	Futures (Shanghai)	Futures (Thailand)	Futures (Tokyo)		
φ_1	0.053963[b]	0.181175[b]	0.000000	0.133146[b]	0.183849[b]		
φ_2	0.923293[a]	0.313669[b]	0.536160	0.460856[a]	0.114573		
AIC	-13.356	-13.218	-12.457	-13.413	-12.577		
SIC	-13.204	-13.066	-12.304	-13.260	-12.425		
Period	**Period III**						
Returns	Futures (London)	Futures (Hong Kong)	Futures (Shanghai)	Futures (Thailand)	Futures (Tokyo)	Futures (Korea)	Futures (Singapore)
φ_1	0.083938[c]	0.072067[b]	0.059830[c]	0.093566[b]	0.083300	0.091486[b]	0.008308[c]
φ_2	0.250730	0.066161	0.529779[b]	0.157162	0.029557	0.336022[b]	0.991682[a]
AIC	-14.067	-13.033	-12.563	-13.039	-12.720	-12.678	-13.249
SIC	-14.006	-12.971	-12.501	-12.977	-12.658	-12.616	-13.188

[a] is 1 percent significant level [b] is 5 percent significant level [c] is 10 percent significant level

Table 4 Hedge ratio and hedging effectiveness

Period	Market by Country	Hedge Ratio				Hedging Effectiveness			
		MVR*	CCC	DCC	BEKK	MVR*	CCC	DCC	BEKK
Period I	Hong Kong	0.5065	0.6421	0.6421	0.6051	0.3138	0.3318	0.3318	0.3412
	Tokyo	0.4035	0.3990	0.3990	0.2871	0.1044	0.1229	0.1229	0.0857
	London	0.8555	0.7289	0.7323	0.7153	0.5126	0.5326	0.6101	0.6571
	Shanghai	0.0220	0.0373	0.0699	0.0877	0.0014	0.0016	0.0176	0.0241
	Thailand	0.3171	0.7397	0.7594	0.7826	0.1761	0.2572	0.3095	0.3252
Period II	Hong Kong	0.7179	0.6447	0.6592	0.6783	0.4446	0.4532	0.4807	0.4612
	Tokyo	0.6114	0.4200	0.4400	0.4278	0.1892	0.2456	0.2819	0.2571
	London	0.6980	0.7123	0.7212	0.7283	0.4950	0.4986	0.5207	0.5515
	Shanghai	0.5076	0.3162	0.3162	0.3842	0.0702	0.1446	0.1446	0.2296
	Thailand	0.6040	0.7040	0.7149	0.7485	0.4023	0.4175	0.4385	0.4730
Period III	Hong Kong	0.5883	0.6182	0.6336	0.6143	0.3210	0.3261	0.3451	0.3331
	Tokyo	0.5734	0.4926	0.5096	0.4814	0.2263	0.2416	0.2615	0.2403
	London	0.8834	0.9102	0.9165	0.9028	0.7692	0.7758	0.7873	0.8467
	Shanghai	0.2764	0.2712	0.2825	0.2935	0.0647	0.0702	0.0794	0.1045
	Thailand	0.5353	0.5692	0.5813	0.5988	0.2849	0.2907	0.3075	0.3229
	Korea	0.4044	0.3873	0.4013	0.4049	0.1437	0.1492	0.1656	0.1651
	Singapore	0.7054	0.6792	0.6254	0.7075	0.4511	0.4607	0.4071	0.6459
Period IV	Hong Kong	0.6397	-	-	0.6749	0.4424	-	-	0.4460
	Tokyo	0.6412	-	-	0.6556	0.3620	-	-	0.3650
	London	0.8434	-	-	0.8816	0.7896	-	-	0.7950
	Shanghai	0.2428	-	-	0.1912	0.0154	-	-	0.0350
	Thailand	0.6798	-	-	0.6555	0.4208	-	-	0.4227
	Korea	0.4219	-	-	0.3663	0.1388	-	-	0.1421
	Singapore	0.7889	-	-	0.7497	0.5542	-	-	0.5621
	Bursa M'sia	0.3269	-	-	0.2552	0.0616	-	-	0.0670
	Indonesia	0.3111	-	-	0.3727	0.1577	-	-	0.1773

MVR is the minimum variance ratio estimated using OLS method.

Table 5 The diagonal bekk garch results

Period I						
Returns	**Spot**	**Futures (London)**	**Futures (Hong Kong)**	**Futures (Shanghai)**	**Futures (Thailand)**	**Futures (Tokyo)**
C	0.000048	0.000198	-0.000134	-0.000126	0.000476	0.000229
C′	0.001017	0.000596	0.003502[a]	0.003756	0.001137[b]	0.000000
		0.001680[a]	0.000000	0.010289	0.000000	0.000000
A	0.231446[a]	0.256178[a]	-0.160734[c]	0.474799	0.094270	0.012572
B	0.963780[a]	0.954033[a]	0.940552	-0.337651	0.985166	0.999665[a]
AIC		-12.784	-12.256	-11.766	-12.549	-11.755
SIC		-12.562	-12.034	-11.544	-12.327	-11.533

Period II						
Returns	**Spot**	**Futures (London)**	**Futures (Hong Kong)**	**Futures (Shanghai)**	**Futures (Thailand)**	**Futures (Tokyo)**
C	0.001103[b]	0.001143[b]	0.001268[b]	0.001044[b]	0.001230[a]	0.001243[c]
C′	0.001852[a]	0.001097[b]	0.003490[a]	0.011584[a]	0.002110	0.009877[a]
		0.000705	0.000000	0.000119	0.000000	0.000000
A	0.165085[b]	0.214653[a]	0.226496[a]	-0.000275	0.226741[a]	0.141683
B	0.971371[a]	0.970665[a]	0.914760[a]	-0.449350	0.950755[a]	0.957907[a]
AIC		-13.370	-13.221	-12.503	-13.411	-12.579
SIC		-13.243	-13.094	-12.377	-13.284	-12.452

Period III								
Returns	**Spot**	**Futures (London)**	**Futures (Hong Kong)**	**Futures (Shanghai)**	**Futures (Thailand)**	**Futures (Tokyo)**	**Futures (Korea)**	**Futures (Singapore)**
C	0.000559[c]	0.000575[b]	0.000499[c]	0.000278	0.000648[b]	0.000542[c]	0.000553[c]	0.000443
C′	0.002309[a]	0.003358[a]	0.000668[b]	0.005286	0.000590[a]	0.002004	0.000614[b]	0.001469
		0.000000	0.001088[c]	0.003687	0.000967[a]	0.002199[a]	0.001415[a]	0.001185
A	0.148346[a]	0.224231a	0.164214[a]	0.463338[a]	0.151501[a]	0.220849[a]	0.160119[a]	0.281884
B	0.970182[a]	0.933498	0.979351[a]	0.758397[a]	0.982687[a]	0.941841	0.977417[a]	0.959443[a]
AIC		-14.090	-13.020	-12.572	-13.045	-12.730	-12.695	-13.272
SIC		-14.039	-12.969	-12.521	-12.993	-12.679	-12.644	-13.220

Period IV										
Returns	**Spot**	**Futures (London)**	**Futures (Hong Kong)**	**Futures (Shanghai)**	**Futures (Thailand)**	**Futures (Tokyo)**	**Futures (Korea)**	**Futures (Singapore)**	**Futures (Bursa Malaysia)**	**Futures (Indonesia)**
C	-0.000420	-0.000409	-0.000572	-0.000505	-0.000559	-0.000540	-0.000373	-0.000504	-0.000556	-0.000830
C′	0.00587[a]	0.00579[a]	0.00470[a]	0.00407[b]	0.004021	0.003996	0.00266[a]	0.00388[a]	0.00178[b]	0.00307[a]

		0.00224^{a}	0.00519^{a}	0.00471^{a}	0.002355	0.000000	0.000000	0.002200	0.00477^{a}	0.000000
	0.174974									
A		-0.153610	0.24703^{a}	0.63954^{a}	0.747200	0.28255^{a}	0.000509	-0.132001	0.000000	0.46291^{c}
	0.58833^{a}									
B		0.508849	0.000000	0.004316	0.167902	0.75900^{c}	0.93397^{a}	0.77349^{a}	0.72119^{a}	0.000088
AIC		-15.572	-14.494	-13.926	-14.544	-14.641	-14.144	-14.926	-13.954	-14.009
SIC		-15.352	-14.274	-13.705	-14.323	-14.421	-13.924	-14.706	-13.734	-13.788

^{a} is 1 percent significant level ^{b} is 5 percent significant level ^{c} is 10 percent significant level

4.5 Hedge Ratio and Hedging Effectiveness

The hedging performance from OLS model (minimum variance ratio) and GARCH models (CCC, DCC and Diagonal BEKK) are compared to unhedge portfolio in Table 4. The hedge ratios are positive and preferably large. Hedge ratio for Thailand market (Period I, global financial crisis) from Diagonal BEKK model is 0.7826. It suggests that one dollar long (buy) in gold spot should be shorted (sold) by about 78.26 cents of gold futures. Similar arguments can be said for the other post crisis periods where the hedge ratios are for Thailand futures market (hedge ratio of 0.7485) in Period II, London futures market (hedge ratio is 0.9028) for Period III and Shanghai futures market (hedge ratio is 0.8816) for Period IV.

For hedging effectiveness, Diagonal BEKK is the best model as compared to CCC and DCC model as well as minimum variance ratio for Hong Kong, London, Shanghai and Thailand markets (0.3412, 0.6571, 0.0241 and 0.3252 respectively). However, for Tokyo market, CCC and DCC model is the best model (0.1229). In Period II, Diagonal BEKK is the best model for London, Shanghai and Thailand markets (0.5515, 0.2296 and 0.4730 respectively). DCC model is the best model for Hong Kong and Tokyo markets (0.4807 and 0.2819 respectively). In Period III, Diagonal BEKK is the best model for London, Shanghai, Thailand and Singapore markets (0.8467, 0.1045, 0.3229 and 0.6459 respectively). DCC model is the best model for Hong Kong, Tokyo and Korea markets (0.3451, 0.2615 and 0.1656 respectively). In Period IV, Diagonal BEKK is the best model for all markets (Hong Kong, Tokyo, London, Shanghai, Thailand, Korea, Singapore, Bursa Malaysia and Indonesia) compared to minimum variance model.

Furthermore, the hedging performances for all markets in Period I (global financial crisis) are less than 66 percent. However, the hedging performances for all markets are reduced by average of 10 percent (to average 55 percent) in Period II and increase by average of 25 percent (to average 80 percent) in Period III and IV (post global financial crisis). Therefore, it can be argued that hedging effectiveness is higher during post global financial crisis as compared to global financial crisis. It is observed that Diagonal BEKK outperformed minimum variance, CCC and DCC models.

5.0 CONCLUSION

Gold prices has an upward trend since 2002 until 2011. Gold prices rising from average 300 US dollars in 2002 to about 1,900 US dollars in 2011. Analysts have identified the trend as a sharp rise and the highest gold prices recorded were in September 2011 of 1,924 US dollars. However, during 2007, the gold prices was slightly decreased due to effect from Asian and Global Financial Crisis. Gold prices had suffered significant drop of more than 25 percent to 37 percent lower than prices recorded in September 2011. Significant drop in gold prices was due to low inflation among countries in the world. In June 2013, world gold prices has experienced substantial fall to around 1,200 US dollars.Results observed that the hedge ratios are positive. For example, hedge ratio for Shanghai market (Period I, during global financial crisis) from Diagonal BEKK model is 0.0877. It suggests that one dollar long (buy) in gold spot should be shorted (sold) by about 8.77 cents of Shanghai gold futures. Furthermore, the hedging performances for all markets in Period I (global financial crisis) are less than 66 percent. However, the hedging performances for all markets are reduced by average of 10 percent (to average 55 percent) in Period II and increase by average of 25 percent (to average 80 percent) in Period III and IV (post global financial crisis).Therefore, it can be argued that hedging effectiveness is higher during post global financial crisis as compared to global financial crisis. However, after global crisis, the hedging effectiveness keep on increasing. It is observed that Diagonal BEKK outperformed minimum variance, CCC and DCC models.

For future research, is it recommended that study on this topic is extended to investigate other types of econometric modelling in order to provide better estimation. Furthermore, future work should examine the long-run relationship between gold and other economic variables such as oil and inflation as well as other types of derivatives markets for instance forwards and options.

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