Thammasat Review of Economic and Social Policy
Volume 5, Number 2, July – December 2019

Received: 1 September 2019
Revised: 30 September 2019
Accepted: 4 December 2019

Time-Varying Risk Aversion: A Dynamic Application in Index Hedging

Aran Phringphred
Research Analyst
Securities and Exchange Commission
Thailand
aran.phring@gmail.com

ABSTRACT

Degree of risk aversion has recently been claimed as important factor in determining hedge ratio level since the conventional minimum variance hedge ratio (MVHR) with risk minimization objective can lead to a suboptimal hedge level. By taking into account investors' risk attitude through their degree of risk aversion and expected return, the risk aversion hedge ratio (RAHR) can help investors maximise their utility. A GARCH-M model was estimated to determine time varying risk aversion (TVRA) and classify short and long hedgers. Multivariate GARCH-DCC model was then applied, to estimate the expected return equation model and conditional variance and covariance models, and to determine the optimal hedge ratio of RAHR. The results revealed that the RAHR portfolio with lower hedge ratio outperformed MVHR portfolio for both short and long hedgers in terms of return, expected utility, risk adjusted returns and hedging cost. Additionally, the positive impact of estimated TVRA on systematic risk of the SET suggests that TVRA might be an alternative sentiment index of SET.

Keywords: Degree of risk aversion, Hedging, GARCH-M, Multivariate GARCH-DCC, Risk management.

JEL Classification: G110, G120, G130, G170

1. Introduction

Hedging is an essential tool to manage the fluctuation in stock and futures prices. To correspond with the realistic hedging in the futures market, this study intends to show other dimensions regarding the hedging perspective. In addition, risk aversion is the key factor in generating different reactions in investment. However, there are technical shortcomings which fail to explain the traditional hedge ratio "Minimum Variance Hedge Ratio (MVHR)". Firstly, several studies, including Ederington (1979), Kumar (2008), Floros and Vougas (2011), as well as Hou and Li (2013), study the estimation of the optimal hedge ratio by presenting MVHR as achieving risk minimizing but failing to consider utility maximizing through risk aversion and expected return, creating a sense of cost disadvantages and higher contracts. Secondly, for MVHR, the distinctions between short and long hedgers are overlooked; the concept of different types of hedgers with different risk attitudes is ignored. Lastly, the degree of risk aversion is the key factor which determines the level of hedge ratio. However, using degree of risk aversion as an arbitrary value, doesn't represent the actual risk attitude of investor resulting in suboptimal hedging (Mehra, 1985, Conlon et al. 2016).

In this study, alternative hedging application is the chief concept for utility maximization. Traditional hedging provides the lowest risk but fails to guarantee investor satisfaction after hedging given that it has a hedge cost and that the investor is likely to lose their return, while this application can help investors have appreciable portfolios by trading off between risk and return. Accordingly "Risk Aversion Hedge Ratio (RAHR)" is crucial for determining the hedging perspective by taking the actual risk attitude into account.

The generalized autoregressive conditional heteroscedasticity in-mean (GARCH-M) model was used to estimate time-varying risk aversion (TVRA) of index market participants in order to apply time-varying hedge ratio while expected return and conditional variance were calculated using multivariate GARCH (MGARCH) dynamic conditional correlation (DCC).

The study employs quadratic utility as the representative of MVHR and RAHR because it describes behaviour in financial markets. The advantages of using quadratic utility RAHR are that (1) it incorporates risk aversion and (2) expects a return to estimate hedge ratio for short and long hedgers. Another useful aspect is that we can measure the utility level through increasing the expected utility, which is the main expectation of the study. However, several papers do not consciously examine the difference between maximizing utility and minimizing variance. They assume that the two different hedging applications are similar. Many studies overlook reality by assuming that the stock and futures prices follow the martingale process, which does not allow an excess return and converts risk aversion to infinity. Consequently, deficiency occurs in the hedging framework.

2. Literature Review

2.1 Hedging Problem

In much of the literature there is no distinction between short and long hedgers because “they may have widely differing reasons for participating in the futures market” (Cotter and Hanly, 2010). The motivation to separate short and long hedgers is caused by an asymmetric performance, which is essential for theoretical and practical purposes. The result corroborates that different types of hedgers tend to have different reactions in the portfolio as determined by risk aversion. According to the study, the degree of risk aversion has to differ in accordance with hedging strategies. Consequentially, they must be considered individually. Demirer et al. (2005) defined the hedging problem for short and long strategies demonstrated in the return of the portfolio as follows:

$$\begin{aligned} R_p &= +xR_s - \beta R_f \quad \text{Short Hedger,} \\ R_p &= -yR_s + \beta R_f \quad \text{Long Hedger,} \end{aligned} \tag{1}$$

where

R_p is the portfolio return,
R_s is the logarithm return of stock price,
R_f is the logarithm return of futures price,
X is the number of contracts for the short position,
Y is the number of contracts for the long position, and
β is the hedge ratio between the short and long hedgers.

2.2 Risk Aversion in the Econometric Framework

Degree of risk aversion is the level of human behaviour when exposed to uncertainty. Generally, degree of risk aversion isn’t constructed by behaviour but it is constructed by volatility index which affects behaviour of humans. The original work on estimation of risk aversion was done by Engle et al. (1987) who estimated risk aversion through three different types of bonds. The primary motivation of time-varying risk aversion stems from the level of uncertainty in asset return changing over time. Consequently, compensation that considers risk aversion from holding the asset has to be time-varying. Thus, increasing the expected rate of returns leads to a significantly high risk. Their research extended ARCH to ARCH-M, which allowed for conditional variance to determine returns. Their result also verifies that conditional variance is significant to explain expected returns but invariant in risk premium.

The next model that Shrestha (2009) extended is GARCH-M. It incorporated conditional variance and a risk aversion parameter instead of unconditional variance. Interestingly, the relationship between risk aversion and excess return was found to be positive since the more risk aversion the higher the required return. The finding by Chou et al. (1992) validated the idea that the risk aversion parameter varies with time because of changing risk preference and investment opportunities. De Goyet et al. (2008) and Brooks et al. (2012) found that risk aversion has an essential effect on the optimal hedge ratio (the agent may wish to exploit the bias in an attempt to trade off risk against return).

Hou and Li (2013) compared two different time-varying hedge ratio models, DCC-GARCH and CCC-GARCH, by using CSI 300 stock index futures. Their result affirms that DCC-GARCH is better than CCC-GARCH in the short horizon because of a high frequency that is fitted to DCC. Moreover, CCC-GARCH outperformed DCC-GARCH in a long time horizon in the sense of hedge effectiveness. Chang et al. (2011) compared BEKK, CCC, DCC, and VARMA-GARCH. The evidence of hedging effectiveness confirms that hedge ratio from DCC is the best model for variance reduction. Meanwhile, diagonal BEKK had the worst performance.

2.3 Utility Function and Hedge Effectiveness

For utility function and hedge effectiveness, the first paper which initiated the concept was Hsin et al. (1994) introduced mean-variance by the expected quadratic utility based on the CRRA framework. This measurement can be interpreted as the increasing quadratic utility between non-hedging and hedging portfolios. The growing utility required high expected return and low volatility. Subsequently, they examined the standard mean variance of hedge effectiveness in the Chinese energy oil market. Lahiani and Guesmi (2014), Cotter and Hanly (2014), as well as Chung-Chu, Tsai-Jung and Chuang (2015) evaluated the hedge ratio by classifying investors between short and long hedgers and employed hedge performances by using expected utility.

Moreover, Chen (2009) explained that the main advantage of choosing quadratic utility is that they considered the risk aversion term and expected return. However, most of the studies assumed that the futures price follows the martingale process. Kroner and Sultan (1993), as well as Lau et al. (2014), reduced the term of the risk aversion to the MVHR. However, in reality, martingale may not hold. Hence, the Risk Aversion Hedge Ratio (RAHR) is deemed as essential to measure by utility increasing given wealth. It meant that variance minimizing is not equal to utility maximizing.

3. Research Methodology

3.1 Coefficient Relative Risk Aversion (CRRA) with Risk Preference

Arrow (1974) and Pratt (1964) developed a theory to measure risk aversion based on quadratic utility functions. A relative risk aversion is the relative percentage invested between holding risk-free and risky assets. Noticeably, the formula in Equation (2) is similar to absolute risk aversion but possesses some difference in scaling relative to the level of wealth. Relative risk aversion can be expressed through:

$$CRRA = -W * \frac{U''(\mathrm{W})}{U'(\mathrm{W})} \qquad (2)$$

W is the investor's wealth

3.1.1 Quadratic Utility Function

Given that the assumption under quadratic utility in the mean-variance framework is optimal, which corresponds with portfolio theory, Markowitz (1952) employed quadratic utility as an instrument in the minimum variance portfolio. Correspondingly, Alexander (2008) and Ederington (1979) employed quadratic utility for optimal hedging

$$U(\mathrm{W}) = W - aW^2, a > 0 \qquad (3)$$

Arrow-Pratt coefficient relative of risk aversion (CRRA):

$$R(\mathrm{W}) = W\left[\frac{2aW}{1-2aW}\right] \qquad (4)$$

W is the investor's wealth

3.1.2 Mean–variance optimization

This study measures the degree of risk aversion by using the mean–variance optimization framework, which is concerned with both mean and variance utility. Frankel (1982, 1983, 1986, 1995) introduced the multicurrency asset-demand equation, where mean and variance are taken to maximize utility by the given end of period wealth. Subsequently, Giovannini and Jorion (1989) developed Frankel's paper, in which they focused on the conditional expected return and the conditional variance over the maximizing utility of investors. This framework is derived in Equations (5) – (12).

$$\max U[\mathrm{E}_t(\mathrm{W}_{t+1}), \sigma_t^2(\mathrm{W}_{t+1})] \tag{5}$$

$$\mathrm{E}_t(\mathrm{W}_{t+1}) = \mathrm{W}_t\ x_t' E_t(\mathrm{R}_{t+1}) + \mathrm{W}_t(1 - x'1)_t R_t^f\ , \tag{6}$$

$$\sigma_t^2(\mathrm{W}_{t+1}) = \mathrm{W}_t^2\ x_t' E\Omega_{t+q} x_t\ , \tag{7}$$

Where

W_t	is the investor's wealth,
R_t^f	is the risk-free rate,
1	is a unit vector,
x_t	is the share of risky assets expressed by a vector
$E_t(R_{t+1})$	is the conditional mean of risky assets,
Ω_{t+1}	is the conditional covariance of risky assets

Thereafter, we differentiate x_t', the vector of portfolio shares:

$$\frac{dU}{dx_t} = U_1 \frac{dE(\mathrm{W}_{t+1})}{dx_t} + U_2 \frac{d\sigma^2(\mathrm{W}_{t+1})}{dx_t} = 0\ . \tag{8}$$

We have *x* that provides a maximized utility

$$x_t = \frac{U_1(R_t^f - E_t(\mathrm{R}_{t+1}))}{2U_2 W_t E_t \Omega_{t+1}}\ . \tag{9}$$

Equation (9) the Sharpe ratio can be rearranged as equation (10):

$$\lambda \Omega_{t+1} x_t = E_t(\mathrm{R}_{t+1}) - R_t^f \, . \qquad (10)$$

Given that $E_t\left(R_{t+1}\right)$ is the actual return, an error term appears as follows:

$$R_{t+1} = R_t^f + \lambda \Omega_{t+1} x_t + \varepsilon_{t+1} \, , \qquad (11)$$

In equation (11), the variable $\Omega_{t+1} x_t$ is the variance of the portfolio that reduces to σ_{pt}^2 and adapts the new equation to (12), which corresponds to GARCH –M model.

$$R_{pt} - R_t^f = \lambda \sigma_{pt}^2 + \varepsilon_t \qquad (12)$$

3.1.3 GARCH in the mean model (GARCH-M)

Engle et al. (1987) and Chou et al. (1992) introduced a degree of risk aversion model, GARCH-M which is a univariate model, which explains the relationship between return and its variance. Regarding hedging strategies, short hedgers open a long position in the stock market and operate a short position for futures. It can be determined that short hedgers are concerned with risk aversion through the stock market because they first make a decision to hold an asset in the stock while for long hedgers it is vice versa. Therefore, long hedgers are concerned with risk aversion based on the futures market. John Y. Campbell and John H. Cochrane (1999) found that the covariance of asset price return is conditionally time-varying, and so too is the relation between the expected risk premium and the variance.

Short hedgers model:
$$R_{\text{Short Hedger},t} = \lambda\sigma^2_{\text{i},t} + \varepsilon_{i,t} \,, \tag{13}$$

$$(R_{\text{Stock},t} - R^f_t) = \lambda\sigma^2_{\text{i},t} + \varepsilon_{i,t} \,. \tag{14}$$

Long hedgers model:
$$R_{Long\ \text{Hedger},t} = \lambda\sigma^2_{\text{i},t} + \varepsilon_{i,t} \,, \tag{15}$$

$$(R_{\text{Futures},t} - R^f_t) = \lambda\sigma^2_{\text{i},t} + \varepsilon_{i,t} \,. \tag{16}$$

Distribution of error term and variance equation follow Equations (17) and (18).

$$[\varepsilon_{i,t}]\big|\Omega_{t-1} \sim N(0, \sigma^2_{i,t}), \tag{17}$$

$$\sigma^2_{\ i,t} = c_i + \alpha_0\varepsilon^2_{\text{i},t-1} + \beta_0\sigma^2_{\text{i},t-1} \,, \tag{18}$$

Where

$R_{\text{Short Hedger},t}$	is the portfolio return of short and long hedgers,
$R_{\text{Long Hedger},t}$	is the portfolio return of short and long hedgers,
λ	is the degree of the risk aversion parameter,
$\varepsilon_{i,t}$	is the error term or the unexpected return,
$\sigma^2_{\ i,t}$	is the variance of the hedged portfolio,
Ω_{t-1}	is the investor information at time t-1.

3.2 Optimal Hedge Ratio and Estimation Technique

3.2.1 Minimum Variance Hedge Ratio (MVHR)

Ederington (1979) and Myers and Thompson (1989) introduced the hedging theory whose objective is to minimize variance after hedging. However, the Minimum Variance Hedge Ratio (MVHR) assumes that the level of risk aversion converges to infinity following equation (19) :

$$\beta = \frac{\sigma_{sft}}{\sigma_{ft}^{2}}, \tag{19}$$

Where

σ_{ft}^{2} is the variance of the SET50 index futures,

σ_{sft} is the covariance between ETF and the SET50 index futures.

3.2.2 Risk Aversion Hedge Ratio (RAHR)

This hedge ratio is based on the quadratic utility function or the mean-variance hedge ratio. For example, Hsin et al. (1994) and Chen et al. (2003) defined a quadratic form that is representative of an investor who is maximizing utility. Cotter and Hanly (2010), as well as Conlon et al. (2016), explained that the futures return does not follow the martingale hypothesis by the following equation (20) :

$$\beta = -\frac{E(\mathrm{r}_{ft})}{2\lambda\sigma_{ft}^{2}} + \frac{\sigma_{sft}}{\sigma_{ft}^{2}}, \tag{20}$$

Where

$E(\mathrm{r}_{ft})$ is the expected return on the SET 50 index futures,

λ is the degree of the risk aversion parameter,

σ_{ft}^{2} is the variance of the SET50 index futures,

σ_{sft} is the covariance between ETF and the SET50 index futures.

3.2.3 Multivariate-GARCH DCC Model

The study employs the M-GARCH DCC, which was introduced by Engle (2000) and Engle and Sheppard (2001). This model is applied to predict variance and expected return according to Massimiliano and Michael (2013), as well as Boffelli and Urga (2016) which captures dynamic correlation of variables to change over time.

$$\begin{aligned} r_{st} &= \mathrm{c}_{11} + \alpha_{11} s_{t-1} + \alpha_{12} s_{t-2} + \alpha_{13} s_{t-3} \\ &+ \beta_{11}\,\mathrm{f}_{t-1} + \beta_{12}\,\mathrm{f}_{t-2} + \beta_{13}\,\mathrm{f}_{t-3} + \varepsilon_{1t} \end{aligned} , \tag{21}$$

$$\begin{aligned} r_{ft} &= \mathrm{c}_{21} + \alpha_{21} s_{t-1} + \alpha_{22} s_{t-2} + \alpha_{23} s_{t-3} \\ &+ \beta_{21}\,\mathrm{f}_{t-1} + \beta_{22}\,\mathrm{f}_{t-2} + \beta_{23}\,\mathrm{f}_{t-3} + \varepsilon_{2t} \end{aligned} \tag{22}$$

$$\varepsilon_{1t,2\mathrm{t}} = \left[\frac{\varepsilon_{st}}{\varepsilon f_t}\right] \Bigg\| \Omega_{t-1} \sim N\left(0, H_t\right), \tag{23}$$

Where

s is the return of stock price

f is the return of futures price

Ω_{t-1} is the information at time t – 1.

Subsequently, the variance equation can be shown as follows:

$$\sigma^2_{st} = c_{ss} + \alpha_{ss}\varepsilon^2_{s,t-1} + \beta_{ss,t-1}\sigma^2_{ss,t-1}, \tag{24}$$

$$\sigma^2_{\mathrm{ft}} = c_{ff} + \alpha_{ff}\varepsilon^2_{\mathrm{f},t-1} + \beta_{\mathrm{ff},t-1}\sigma^2_{\mathrm{ff},t-1}, \tag{25}$$

$$\sigma^2_{sft} = c_{sf} + \alpha_{sf}\varepsilon_{s,t-1}\varepsilon_{f,t-1} + \beta_{sf,t-1}\sigma^2_{sf,t-1}. \tag{26}$$

The formula for the substitute of the time-varying conditional correlation is

$$\rho_t = \frac{\sigma_{sft}}{\sqrt{\sigma_{\mathrm{s}t} * \sigma_{\mathrm{ft}}}}, i \neq j, \tag{27}$$

Where

σ_{sft} is the conditional covariance between the stock and futures time t,

σ^2_{st} is the conditional variance of the stock at time *t*,

σ^2_{ft} is the conditional variance of the futures at time *t*.

3.3 Hedging Performance

3.3.1 Average Return

The average returns is the main performance to measure among MVHR, RAHR and Unhedged positon (UH). The study transforms return to an average return to conveniently interpret it. Demirer et al. (2005) and Cotter and Hanly (2010) set the beta as the hedge ratio as determined in the portfolio return.

$$R_p = +xR_s - \beta R_f \quad \text{Short Hedger,} \tag{28}$$

$$R_p = -yR_s + \beta R_f \quad \text{Long Hedger,} \tag{29}$$

Where

R_p is the portfolio returns,
R_s is the log return of the SET50 index,
R_f is the log return of the SET50 index futures,
X is the number of contracts for the short position,
Y is the number of contracts for the long position, and
β is the hedge ratio.

3.3.2 Variance

The return outlined in sub-section 3.3.1 is transformed to the variance term proposed by Floros and Vougas (2006). The study compares the variance of hedged position(H) with the MVHR, the RAHR, and the unhedged position (UH).

$$Var(\mathrm{H}) = \sigma_s^2 + \beta^{2*}\sigma_f^2 - 2\beta^*\sigma_{sf} \; . \tag{30}$$

$$Var(\mathrm{UH}) = \sigma_s^2 \; . \tag{31}$$

Where
σ_s^2 is a variance of the stock return,
σ_f^2 is a variance of the futures return,
σ_{sf} is a covariance between stock and future returns
β is the hedge ratio.

3.3.3 Hedge Effectiveness of Variance Minimization

According to Yuan-Hung Hsu et al. (2007), to construct and effectively utilize an accurate model, we have to obtain the efficient conditional volatility. This approach is the efficient minimum-variance presented by Ederington (1979), Yang et al. (2001) whose objective is to compare the effectiveness of the simple hedge ratio and the alternative hedge ratio.

$$Hedge\,Effectiveness \quad 1-\frac{\text{Variance(Hedged)}}{Variance\text{(Unhedged)}} \tag{32}$$

$$Hedge\,Effectiveness = 1-\frac{(\sigma_s^2 + h^{2*}\sigma_f^2 - 2h^*\sigma_{s,f})}{\sigma_s^2}\,. \tag{33}$$

Where

σ_s^2	is a variance of the stock return,
σ_f^2	is a variance of the futures return,
$\sigma_{s,f}$	is a covariance between stock and futures returns,
h	is the computed hedge ratio.

3.3.4 Utility Increasing

Hsin et al. (1994) and Cotter and Hanly (2010, 2012, 2014) assumed that hedgers' behaviour can be represented as a quadratic utility function. Therefore, hedging decision depends on a mean-variance framework to maximize their expected utility. In this process, hedge effectiveness in the sense of utility is measured by the percentage of increase of their quadratic utility. However, the study compares increasing utility between the MVHR and the RAHR to find the distinction between two different hedge ratios.

$$Hedge\ Effectiveness = V(\mathrm{E}(\mathrm{r}_{pt}), \sigma_{pt}; \lambda_0), \quad (34)$$

$$\underset{w_f}{Max}\, V(\mathrm{E}(\mathrm{r}), \sigma; \lambda)) = \mathrm{E}(\mathrm{r}_{pt}) - 0.5\lambda\sigma_H^2, \quad (35)$$

Where

$E(r_{pt})$ is the expected return of short and long hedgers and stocks,

σ^2_{pt} is the variance of both short and long hedgers and stocks,

λ is the degree of risk aversion estimated from GARCH-M.

3.3.5 Sharpe Ratio

The Sharpe ratio (Sharpe, 2007) is a measure of investment performance concerning the risk-adjusted return. The Sharpe ratio is formulated by using the excess portfolio return over the risk-free rate relative to its standard deviation or variance. Sharpe ratio's criterion is a portfolio in which the higher the Sharpe ratio, the more return the hedger receives per unit. If two hedging applications offer the same returns, then the one with a low standard deviation will have a high Sharpe ratio.

$$Sharpe\,ratio\ \ Sharpe\,ratio$$

$$Sharpe\,ratio = \frac{(\mathrm{R}_p - \mathrm{R}_f)}{\sigma} \quad (36)$$

Where

R_p is a portfolio return,

R_f is a risk-free rate return,

σ is a standard deviation.

3.3.6 Optimal Number of Futures Contracts and Hedging Cost

To calculate hedging cost, the paper intends to calculate optimal number of futures contracts in order to compare cost performance between MVHR and RAHR. In this case , the paper assumes that portfolio value equal to 5 million and the contract multiplier equal to THB 200 per index point which is referred from Thailand Futures Exchange (TFEX). The equation follows as:

$$N^* = \beta_i \left(\frac{P_B}{Q_F}\right) \tag{37}$$

Where

β_i is hedge ratios of MVHR and RAHR,
P_B is current portfolio value (Baht),
Q_f is current value of futures contract on index (units).

After we obtain the optimal number of futures contracts, the next step is to calculate the hedging cost which is defined as the number multiplied with the price. In this case, the paper takes price (exchange fee) from TFEX which is equal to THB 7 per contract:

$$Hedging\,Cost = N^* \times \mathrm{P} \tag{38}$$

Where

N^* is optimal number of futures contracts
P is futures price per contract

4. Empirical Result

4.1 Data Description and Unit root test

The daily data is from TDEX SET50 ETF and SET50 index futures which was gathered between 06/09/2007 and 29/12/2017 from Bloomberg. The research also looks at the three month treasury-bill rates as the risk-free rate between 06/09/2006 and 29/12/2017, obtained from the ThaiBMA. The study intends to cover both the normal period and financial crisis which have fluctuated the market and changed hedging strategy such as during Greece's debt crisis, Brexit and also, the political instability problem in Thailand. Subsequently, this data set is adjusted to logarithmic returns.

4.2 Estimation of Risk Aversion in the TDEX ETF and SET50 Index Futures

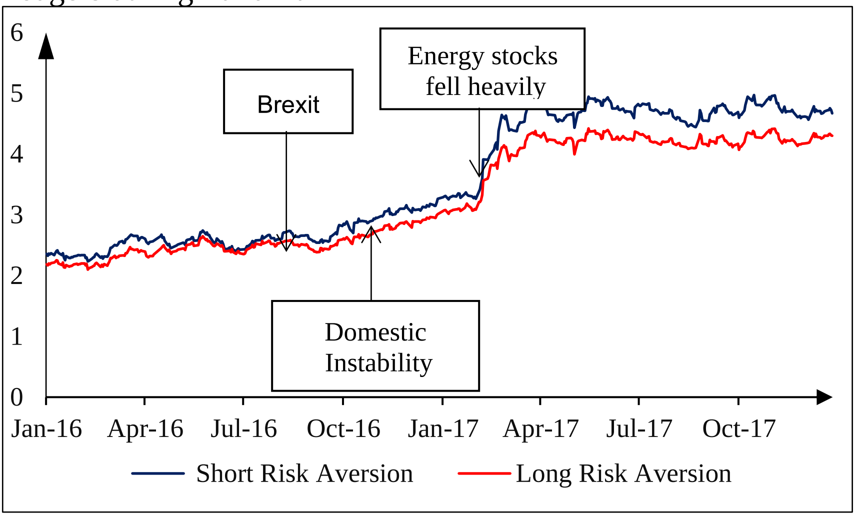
Table 1. Time rolling window of risk aversion between short and long hedgers

	Coefficient Relative of Risk Aversion		
Daily	Short Hedgers (TDEX SET50 ETF)	Long Hedgers (SET50 Index Futures)	t-stat (Testing Difference)
Observations	488	488	
Mean	3.5852*	3.2899**	39.8274***
Min	2.2342	2.0984	
Max	4.9708	4.4210	
Std.	1.0084	0.8540	

Source : Author's Calculation
Note: ***, **, and * denote significance by using t-test at the 1%, 5%, and 10% levels, respectively.

The GARCH-M is employed to determine the characteristic of risk aversion. Correspondingly, time rolling window provides the TVRA to construct the time-varying hedge ratio (TVHR). In table 1, the results showed that the average risk aversion for short and long hedgers is approximately 3.6 and 3.3. These results are consistent with Engle et al. (1987), Chou et al. (1992), as well as Cotter and Hanly (2015) who found the evidence of the risk aversion parameter in the range of 0–4 by using GARCH-M. Subsequently, using pair t-test demonstrates that short and long hedgers at the 1% level have statistically significant differences, implying that the difference in the degree of risk aversion for short and long hedgers brings about different hedging strategies, which are described in the second objective.

Figure 1. Time-varying risk aversion between short and long hedgers during 2016-2017



Source: Author's Calculation

In comparison with the degree of risk aversion of long hedgers, short hedgers tend to be more risk-averse than long hedgers. The results affirmed that short hedgers react to price change, whereas long hedgers react to price inelasticity. By contrast, Demirer et al. (2005) and Cotter and Hanly (2010) confirmed that consumers react more than producers when it comes to hedging. In addition, several reasons to support this contrast emerge. First, these structures differ because these studies focus on the commodity market, whereas this study concerns the index market. Second, the study uses daily data while Cotter and Hanly (2014) used weekly and monthly data.

Figure 1 shows the risk aversion parameter was high in October 2016 due to the demise of the King. After that, they significantly increased by almost twofold because energy stocks fell heavily (especially due to PTT which has the highest market capitalization in SET50), during February 2017. This scenario indicates that, during economic recession, risk aversion increases and that, during economic progress, risk aversion diminishes. Therefore, TVRA has an opposite relationship with the business cycle, called "countercyclical". These findings correspond with Brandt and Wang (2003), Kim (2014), as well as Cohn et al. (2015) who proposed that risk aversion parameters are "countercyclical" and given by boom and bust scenarios.

4.3 Optimal Hedging Strategies

The second objective has two main parts. The first part is the comparison between the MVHR and the RAHR. The RAHR incorporates the risk aversion parameter from the first objective based on quadratic utility in- and out-sample. The other part examines the statistical difference between risk minimization and utility maximization using a t-test to ensure that the RAHR can be an alternative hedging concept. Table 2 exhibits two different hedge ratios in-sample. To construct the time-varying hedge ratio (TVHR), the study predicts variance and covariance by using dynamic conditional correlation (DCC) to applied MVHR and RAHR. In the case of short hedgers, the MVHR ranges between 0.7829 and 0.7951 with the average at 0.7931. If short hedgers hold the TDEX SET50 ETF for 1 unit, then they will on average sell the SET50 index futures at 0.7931. Using RAHR, the range is from 0.3982 to 0.6881 with the mean at 0.4959. If short hedgers hold the TDEX SET50 ETF for 1 unit, then they will on average sell the SET50 index futures at 0.4959 or 0.5 contracts.

Table 2. Comparison between Risk Aversion Hedge Ratio (RAHR) and the Minimum Variance Hedge Ratio (MVHR) - (in-sample)

Daily	Panel 1: Short Hedgers			Panel 2: Long Hedgers		
	RAHR	MVHR	t-stat	RAHR	MVHR	t-stat
Obs	488	488	-101.92***	488	488	-110.43***
Mean	0.4959	0.7931		0.4724	0.7931	
Min	0.3982	0.7829		0.3663	0.7829	
Max	0.6881	0.7951		0.6793	0.7951	
Stdev	0.0644	0.0011		0.0641	0.0011	

Source : Author's Calculation
Note: ***, **, and * denote significance by using t-test at the 1%, 5% and 10% levels, respectively.

Table 3 provides a summary for the hedge strategies from out-sample. The reason for construction of the out-sample is to compare with future performance. Accordingly, one-step advance forecast for 100 observations is applied to the study. The average of MVHR of both short and long hedgers are 0.7933 unit. For short hedgers, the RAHR ranges from 0.3938 to 0.6873 with Aamean of 0.4955. For long hedgers, the RAHR ranges from 0.3658 to 0.6784 with the mean average at 0.4720. The results from in-sample and out-sample confirm that the RAHR and MVHR ranges are statically different.

Table 3. Comparison between Risk Aversion Hedge Ratio (RAHR) and the Minimum Variance Hedge Ratio (MVHR) - (out-sample)

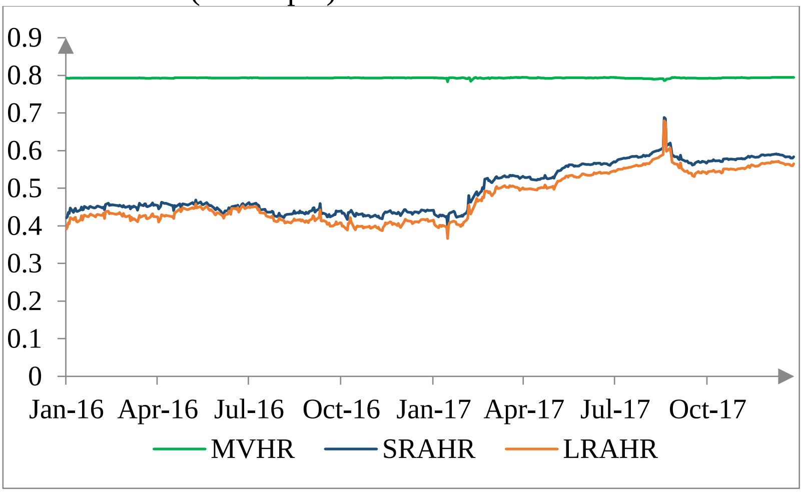
Daily	Panel 1: Short Hedgers			Panel 2: Long Hedgers		
	RAHR	MVHR	t-stat	RAHR	MVHR	t-stat
Obs	488	488	-101.91***	488	488	-110.43***
Mean	0.4955	0.7933		0.4720	0.7933	
Min	0.3978	0.7831		0.3658	0.7831	
Max	0.6873	0.7954		0.6784	0.7954	
Stdev	0.0656	0.0011		0.0643	0.0011	

Source : Author's Calculation
Note: ***, **, and * denote significance by using t-test at the 1%, 5% and 10% levels, respectively.

Both sample periods consistently report the outcome that short hedgers have higher risk aversion than long hedgers and possibly have a higher hedge ratio in their portfolio when using the RAHR, whereas the MVHR does not make the distinction between the two different hedgers. However, this objective has clearly implied that conducting a TVRA influences the optimal hedging strategies by using the RAHR.

Figure 2 depicts the MVHR, RAHR (short), and RAHR (long) for in-sample and Figures 3 with the out-sample. It can seen in the figure 1 that a negative financial situation affected RAHR. Consequently, risk aversion increased and forced hedgers to use a high RAHR in 2017, whereas the MVHR remained stable for the whole period. Figures 4 and 5 provide the scatter plots for the positive relationship between CRRA and the RAHR between short and long hedgers in-sample and out-sample. Moreover, all cases imply that increase in risk aversion results to significant more use hedge ratio.

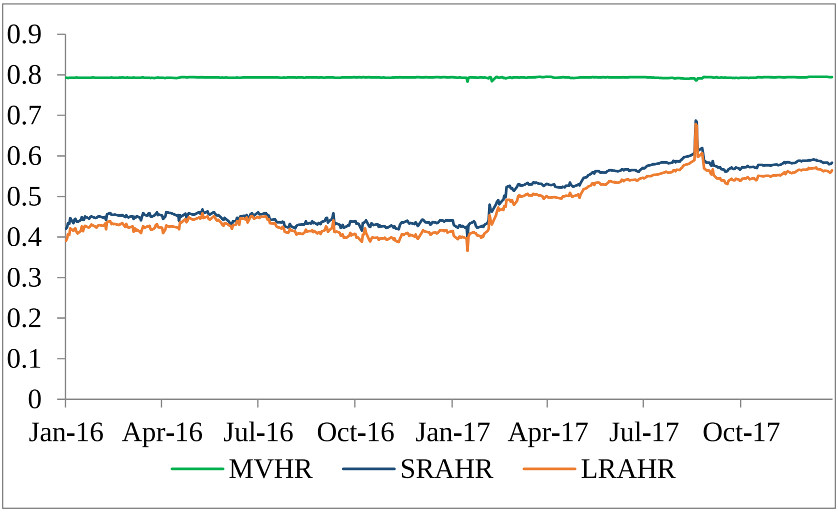
Figure 2. Time-varying optimal hedge ratios between MVHR and RAHR – (in-sample)



Source : Author's Calculation

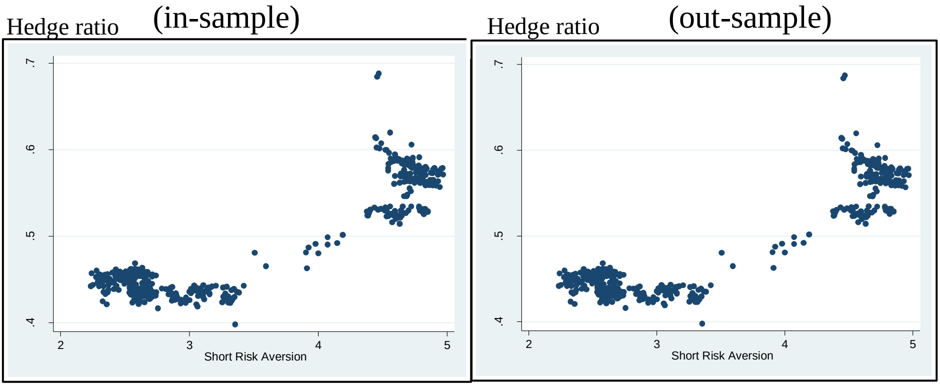
The second part is the t-test which is employed to explain the difference between hedging strategies in table 2 and 3. The result affirms that, at the 0.05% level, statistically significant differences occur between risk minimization (MVHR) and utility maximization (short and long RAHR) both in-sample and out-sample. Consequently, if an investor wishes to have the lowest risk, then the MVHR may work. However, if an investor intends to speculate, then the RAHR may be better. Nonetheless, all cases of the RAHR are lower than those of the MVHR, which can be explained by the fact that the actual risk averse is taken into account. The RAHR for short and long hedgers will exhibit reality by using hedge ratios because the RAHR is based on actual aggregate risk aversion, whereas the MVHR assumes that risk aversion converges to infinity.

Figure 3. Time-varying optimal hedge ratios between MVHR and RAHR – (out-sample)



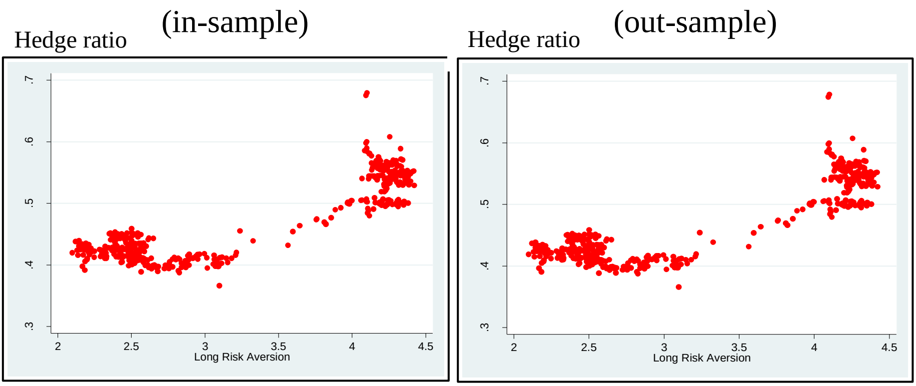
Source : Author's Calculation

Figure 4. The relationship between the risk aversion and the RAHR - Short hedgers



Source: Author’s Calculation

Figure 5. The relationship between the risk aversion and the RAHR - Long hedgers



Source: Author’s Calculation

4.4 Hedging Performance

The MVHR, the RAHR, and the UH are compared based on their performance. Time-varying risk aversion (TVRA) provides 488 values for the result. Therefore, tables 4 and 5 are exhibited as the average value instead. Table 4 displays in-sample performance and clearly shows that short hedgers have a good performance in terms of the RAHR. For example, with regards to the return, short hedgers receive a high rate in the RAHR with 0.025734%, whereas the MVHR provides 0.006697%. Interestingly, the performance of expected utility which is the main aim of the study shows that using RAHR provides higher utility than using MVHR. The RAHR offers increasing utility at 0.017803% whereas MVHR just gives 0.002800%. For other performances, the Sharpe ratio shows that RAHR is greater in risk-adjusted than MVHR.

Table 4. Hedging performance - (in-sample)

	Panel 1: Short Hedgers			Panel 2: Long Hedgers		
	($\times 10^{-4}$)	($\times 10^{-4}$)	($\times 10^{-4}$)	($\times 10^{-4}$)	($\times 10^{-4}$)	($\times 10^{-4}$)
	RAHR	MVHR	Unhedged	RAHR	MVHR	Unhedged
Return	2.5734	0.6697	6.4072	-2.6628	-0.6697	-6.4072
Variance	0.4449	0.2174	1.7517	0.4801	0.2174	1.7517
EU	1.7760	0.2800	3.2672	-3.4526	-1.0274	-9.2888
	($\times 10^{2}$)	($\times 10^{2}$)	($\times 10^{2}$)	($\times 10^{2}$)	($\times 10^{2}$)	($\times 10^{2}$)
HE	0.7474	0.8759	0	0.7273	0.8759	0
SR	3.6971	0.6292	4.5232	-4.8057	-2.2447	-5.0923
OC	13	21	-	13	21	-
HC	91	147	-	91	147	-

Source: Author’s Calculation

In addition, this study also measures optimal number of futures contracts and hedging cost to confirm that RAHR perform in term of contracts cost by supposing that investor portfolio is Baht 5 million. Comparing between two hedge ratio model show that optimal number of futures contracts of RAHR used at 13 is less than MVHR at 21. Therefore, the result also illustrates that RAHR can reduce contracts cost than MVHR by around 1.62 times. However, MVHR outperform in term of variance which provides the lowest variance compared to RAHR and UH. This is similar to hedge effectiveness, where MVHR can reduce variance to 88% while RAHR is at 75%. The result confirms a trade-off between risk and return if investors pursue minimizing risk; they have to accept the low return from using the MVHR.

Table 5. Hedging performance - (out-sample)

	Panel 1: Short Hedgers			Panel 2: Long Hedgers		
	($\times10^{-4}$)	($\times10^{-4}$)	($\times10^{-4}$)	($\times10^{-4}$)	($\times10^{-4}$)	($\times10^{-4}$)
	RAHR	MVHR	Unhedged	RAHR	MVHR	Unhedged
Return	2.5767	0.6684	6.4072	-2.6664	-0.6684	-6.4072
Variance	0.4443	0.2165	1.7474	0.4796	0.2165	1.7474
EU	1.7803	0.2803	3.2749	-3.4553	-1.0245	-9.2817
	($\times10^{2}$)	($\times10^{2}$)	($\times10^{2}$)	($\times10^{2}$)	($\times10^{2}$)	($\times10^{2}$)
HE	0.7471	0.8761	0	0.7269	0.8761	0
SR	3.7088	0.6362	4.5293	-4.8176	-2.2552	-5.0991
OC	13	21	-	13	21	-
HC	91	147	-	91	147	-

Source: Author's Calculation

Note1: Return, Variance, Expected Utility (EU), Sharpe Ratio (SR), Hedging Effectiveness (HE), Optimal Number of Futures Contracts (OC) and Hedging Cost (HC) are displayed for the RAHR, the MVHR, and a No hedge position (UH).
Note2: Optimal number of futures contracts equals to β(① / ② * ③) (Given that ①. Portfolio value = 5 million ②.Mean of futures price = 963.6 ③. Multiplier = 200 and Heding Cost equal to OC*④ which ④.exchange fee = 7 THB per contract side)

For long hedgers, MVHR performed better than RAHR. The return of MVHR is -0.006697% while RAHR is -0.026628% in which MVHR provides a higher return than using RAHR. The variance of MVHR is lower than RAHR whereas UH still has the highest variance. For expected utility and Sharpe ratio MVHR was higher than RAHR as shown by the negative value. As for hedge effectiveness, the MVHR has the lowest risk at 88% reduction. In long hedgers' perspective, RAHR variance reduction risk is 73%.

Table 5 focuses on out-sample performance. Comparing the results between RAHR and MVHR are almost consistent result with the in-sample. The main result shows that MVHR is still eclipsed by RAHR for short hedgers. In RAHR's mean of return performance, short hedgers have a rate of return at 0.025767% while MVHR is 0.006684%. Accordingly, out sample of RAHR provides every point of return on bearing units of risk which is higher when MVHR is used. In the same way expected quadratic utility for RAHR is increasing at 0.017803% which higher that of MVHR just increases at 0.002803%. Also Sharpe ratios of RAHR provide a higher risk-adjusted return than MVHR. Measuring optimal contracts and hedging cost is consistent with in-sample that RAHR can save the cost than MVHR. For variance, MVHR also still performs with the lowest variance compared with RAHR and UH. Hedge effectiveness provides the lowest risk for MVHR at 88% reduction whereas RAHR plays a risk reduction at 75%. Overall, short hedgers perform better in RAHR than MVHR. For long hedgers, the result exhibits the same as in the sample. If long hedgers intend to measure the futures performance, they still prefer to use MVHR to hedging than RAHR.

Both in-sample and out-sample show interesting results that short hedgers tend to have the better performance than long hedgers. Noticeably, in the in-sample and out-sample of Unhedged position, although it provides higher utility than RAHR, it obtains the higher risk which corresponds with the high-risk high-return belief. Another point is unhedged position which only invests in the stock market (TDEX SET50 ETF) and not concern the relationship between two difference market so there are not related in the hedging framework. However, both strategies imply that RAHR is potentially weightier on utility and risk whereas MVHR focuses only in minimizing risk. Otherwise, there is still uncertainty on determining which strategy will perform better, we could follow the cue that for short hedgers RAHR may work same as long hedger prefer to hedge with MVHR.

5. Conclusion

5.1 Summary

In this study, GARCH-M is employed and derived from the mean–variance optimization framework and estimates the relationship between risk and variance. The attitudes of short and long hedgers toward risk are also explained by CRRA through the index financial market which is the TDEX SET50 ETF and SET50 Index Futures. Time rolling window is then used as proxies to ensure a stable coefficient. Thereafter, two types of hedge ratio are constructed using the variance and covariance and are predicted in multivariate GARCH-DCC. In addition, testing current performance and forecasting future performance provide the present attitude of hedgers against futures attitude.

Empirical findings show that the degree of risk aversion is an essential input that clearly affects the choice of index hedging strategy. The positive relationship between the degree of risk aversion and hedge ratio, which means that when facing high risk aversion, hedgers tend to spend more on the hedge ratio. Also, significant statistical and economical difference exists between RAHR and MVHR. It means that Utility Maximizing and Risk Minimizing are different. In the same way, when actual risk aversion is incorporated into the hedge ratio, a lower hedge ratio is observed than the assumed infinity risk which affects the cost. Furthermore, the risk preferences of the hedger changes over time which is especially true in the recent timeframe. The risk aversion of the two hedgers decreased in 2016 and increased over twofold in 2017 which can be a sentiment index for investors.

For hedging performance, this study proposed an average risk aversion parameter as this appropriately represents as mean. These findings present RAHR of short hedgers as superior to long hedgers in terms of portfolio average return, utility, Sharpe ratio, and hedging cost. A greater expected utility means that there is more satisfaction from using RAHR than MVHR due to trading off between risk and return, as well as optimal contracts which RAHR can reduce hedging cost than MVHR. For long hedgers, RAHR is eclipsed by MVHR in both in- and out-samples. The comparison between in- and out-samples of short and long hedgers explain that the in-sample possibly performs consistently with the out-sample.

The overall comparison of two different hedge ratios show that the advantages from using RAHR are as follows: first, RAHR incorporates the degree of risk aversion. This phenomenon means that the hedge ratio, based on actual investor risk aversion, varies in the Thailand economy, whereas that of MVHR assumes that risk aversion converges to infinity, leading to a constant and suboptimal hedging framework. Second, RAHR can hold the concept of hedging strategies between short and long hedgers, whereas MVHR ignores the variations in types of hedgers with different risk attitudes.

5.2 Discussion

The study has looked at three issues regarding hedging. The first part of the study in which risk aversion parameter varied over time as supported by Engle et al. (1987), Chou et al. (1992), and Ann and Shrestha (2009), explained that changing economic structures, market imperfections, and incomplete information affect the attitude of investors toward risk. Consequently, Cotter and Hanly (2010) explained that TVRA causes an inconstant risk bearing among investors. Moreover, TVRA has a contradictory relationship with the Thailand business cycle. These findings correspond with those by Brandt and Wang (2003), Kim (2014), and Cohn et al. (2015), who found that risk aversion parameter is counter-cyclical and corresponds to a boom and bust scenario.

The significant differences between RAHR and MVHR have economic importance; subsequently, when explicit risk aversion is considered, expected utility and risk minimizing are substantially different. Another finding is that the estimation of RAHR is generally lower than MVHR because the latter is under the assumption of risk aversion, which converges to infinity. This finding is consistent with the actual situation wherein investors do not need to receive high-risk aversion because it causes cost disadvantage, which further corresponds with the results by Cotter and Hanly (2010). Therefore, the measurement of expected utility by Hsin et al. (1994) and Chen (2009) led to the advantages of using RAHR, which reflect hedger disapproval in demanding high hedge ratios. Finally, hedgers are satisfied because they receive high net benefits.

5.3 Policy Implications

Regulators

To understand investor’s risk preference (risk aversion), Stock Exchange of Thailand (SET) should implement a domestic degree of risk aversion as an investor sentiment index to decide between economic recession and recovery, and Bank of Thailand (BOT) can set the monetary policy to maintain financial stability. For example, Chuang et al. (2010) explains that “a proxy for investor sentiment to demonstrate the impact of investor sentiment on excess returns in stock market. Therefore, investors usually observe the change in trading volume first and then make their investment decisions”. Another example is shown by Mishra's (2014) “investors’ risk preference which is vital for central banks so as to set suitable the monetary policy that support central bank credibility and eliminate macroeconomic ambiguity”. In addition, during high risk aversion BOT can use the expansionary monetary policy to stabilize the economy.

Investors and Intermediaries

In this era, the VUCA world has also affected the capital market sector, causing investors to be concerned about high capital loss. Having the sentiment hedging technique will help investors to better manage the risk. This study outlines the benefits of hedging model; first it provides higher returns than the original model. Similarly, investors do not require lot of contracts to hedge which leads to an unnecessary cost of hedging. Therefore, this study sees the importance of the degree of risk aversion, reflecting the various states of capital markets. This concept is useful not only in terms of the usage of derivatives, but also other securities such as mutual fund, ETF, options and warrants.

Degree of risk aversion in this context is reflected by the volatility of SET 50 index. It is based on the fact that the more investors' concern, the higher the volatility. Rising risk aversion is a growing concern. Normally, the increasing concern leads to higher market volatility. For instance, if stock price rises, investors will sell out because they are hesitant and buy more stocks because they are anxious. Second, risk aversion is constructed from the aggregate risk aversion which is a good way for investors who use this index as a benchmark. Nonetheless, it cannot precisely reflect individual risk aversion because putting individual risk aversion leads to individual bias.

This concept is also useful for intermediaries in a way to reduce currency risk from investing aboard or investing in other exchanges. Another issue is promoting the performance to reduce costs from investing in mutual funds. This finding is a significant advantage. That is, fund managers could reduce transaction costs which, in turn, increases the returns to his clients.

5.4 Limitation

There is a limitation for using risk aversion index. The risk aversion index in this context is inspired by the VIX index in the United States which it is constructed by implied volatility from options. Similarly, this volatility can reflect volatility in the future while risk aversion from this study is calculated from the historical volatility which the calculation is based on historical data.

However, creating VIX Index is quite difficult to apply in case of Thailand because the liquidity of options is very small compared to the liquidity in the United States. Therefore, it may not be able to reflect the actual risk aversion. At this stage, the use of risk aversion index is still currently appropriate index because it is calculated from set index, being the main index in Thailand and also represents high liquidity. Therefore, in the sense of using the index proposed in this paper, the user should aware of the fundamentals of the model.

References

Alexander C. (2008). Market risk analysis. John Wiley & Sons, Chichester.

Arrow, K.J. (1974). Essays in the theory of risk-bearing. Amsterdam: North-Holland Pub. Co.

Boffelli S., Urga G. (2016). Financial econometrics using Stata. College Station, Texas.

Brandt M.W., & Wang K.Q. (2003). Time-varying risk aversion and unexpected inflation. *Journal of Monetary Economics, 50*, 1457-1498.

Brooks C., Černý A., & Miffre J. (2012). Optimal hedging with higher moments. *Journal of Futures Markets, 32*, 909-944.

Campbell J.Y. (2003). Consumption-based asset pricing. In Constantinides, G., Harris, M. & Stulz, R. (Eds.) *Handbook of the Economics of Finance* (pp.803-887).

Campbell, J., & Cochrane, J. (1999) By Force of Habit: A Consumption-Based Explanation of Aggregate Stock Market Behaviour. *Journal of Political Economy, 205*.

Chang C.-L., McAleer M., & Tansuchat R. (2011). Crude oil hedging strategies using dynamic multivariate GARCH. *Energy Economics, 33*, 912-923.

Chen S.-S., Lee C.-f., & Shrestha K. (2003). Futures hedge ratios: a review. *Quarterly Review of Economics and Finance, 43*, 433-465.

Chen W. (2009). Three essays on, Hedging in China's oil futures market; Gold, oil and stock market price volatility links in the USA; and, Currency fluctuations in S.E. and Pacific Asia, University of Birmingham.

Chou R., Engle R.F., & Kane A. (1992). Measuring risk aversion from excess returns on a stock index. *Journal of Econometrics, 201-204 Volume 52, Issue1-2*.

Chuang W.J., Ouyang L.Y., & Lo W.C. (2010). The Impact of Investor Sentiment on Excess Returns: A Taiwan Stock Market Case, Tamkang University, Taiwan.

Chung-Chu Chuanga Y.-H.W., Tsai-Jung Yeha, & Chuang a.S.-L. (2015). Hedging effectiveness of the hedged portfolio: the expected utility maximization subject to the value-at-risk approach. *Applied Economics, 47*.

Cohn A., Engelmann J., Fehr E., & Maréchal M.A. (2015). Evidence for countercyclical risk aversion: an experiment with financial professionals. *American Economic Review*, *105*, 860-885.

Conlon T., Cotter J., & Gençay R. (2016). Commodity futures hedging, risk aversion and the hedging horizon. *European Journal of Finance*, *22*, 1534-1560.

Cotter J., & Hanly J. (2010). Time-varying risk aversion: An application to energy hedging. *Energy Economics*, *32*, 432-441.

Cotter J., & Hanly J. (2012). A utility based approach to energy hedging. *Energy Economics*, *34*, 817-827.

Cotter J., & Hanly J. (2014) Performance of utility based hedges. Dublin.

De Goyet C.D.V., Dhaene G., & Sercu P. (2008). Testing the martingale hypothesis for futures prices:

Implications for hedgers. Journal of Futures Markets 28:1040-1065.

Demirer R., Lien D., & Shaffer D.R. (2005). Comparisons of short and long hedge performance: the case of Taiwan. *Journal of Multinational Financial Management*, *15*, 51-66.

Ederington L.H. (1979). The Hedging Performance of the New Futures Markets. *Journal of Finance*, *34*, 157-170.

Engle R.F. (2000). Dynamic conditional correlation: a simple class of multivariate GARCH models. La Jolla, *Journal of Bussiness & Economic Statistics*, *20* (3), 339-350.

Engle R.F., Lilien D.M., & Robins R.P. (1987). Estimating Time Varying Risk Premia in the Term Structure: The Arch-M Model, *Econometrica*. *55*,(2).

Engle R.F., & Sheppard K.K. (2001). Theoretical and Empirical Properties of Dynamic Conditional Correlation Multivariate GARCH, Department of Economics, University of California at San Diego, Economics Working Paper Series.

Epstein L.G., & Zin S.E. (1991). Substitution, risk aversion, and the temporal behaviour of consumption and asset returns: an empirical analysis. *Journal of Political Economy*, *263*.

Floros C., & Vougas D.V. (2006). Hedging Effectiveness in Greek Stock Index Futures Market, 1999-2001. *International Research, Jornal of Finance and Economics*, 5, 17-18.

Frankel J.A. (1982). In search of the exchange risk premium: a six-currency test assuming mean-variance optimization. *Journal of International Money and Finance*, *1*, 255-274.

Frankel J.A. (1983). Estimation of portfolio-balance functions that are mean-variance optimizing. *European Economic Review*, *23*, 315-327.

Frankel J.A. (1986). The Implications of Mean-Variance Optimization for Four Questions in International Macroeconomics. NBER Working Papers No.1617.

Frankel J.A. (1995). Do Asset-Demand Functions Optimize over the Mean and Variance of Real Returns? A Six-Currency Test, in: J. A. Frankel (Ed.), *Financial Markets and Monetary Polic*y, Cambridge and London: MIT Press. pp. 49-58.

Giovannini A., Jorion P. (1989). The Time Variation of Risk and Return in the Foreign Exchange and Stock Markets. *Journal of Finance*, *44*, 307-325.

Hou Y., & Li S. (2013). Hedging performance of Chinese stock index futures: An empirical analysis using wavelet analysis and flexible bivariate GARCH approaches. *Pacific-Basin Finance Journal*, *24*, 109-131.

Hsin C.-W., Kuo J., & Lee C.-F. (1994). A new measure to compare the hedging effectiveness of foreign currency futures versus options, John Wiley & Sons, J*ornal of Futures Markets*, *14*(6), *685-707*.

Kim K.H. (2014). Counter-cyclical risk aversion. *Journal of Empirical Finance*, *29*, 384-401.

Kroner K.F., & Sultan J. (1993). Time-Varying Distributions and Dynamic Hedging with Foreign Currency Futures. *Journal of Financial & Quantitative Analysis, 28,* 535-551.

Kumar S., Pandey. (2008). Hedging Effectiveness of Constant and Time Varying Hedge Ratio in Indian Stock and Commodity Futures Markets, SSRN Electronic Journal

Lahiani A., & Guesmi K. (2014) Commodity Price Correlation and Time Varying Hedge Ratios. *Journal of Applied Business Research*, *30, 1053-1061*.

Lau M.C.K., Su Y., Tan N., & Zhang Z. (2014). Hedging China's energy oil market risks. *Eurasian Economic Review*, *4*, 99-112.

Markowitz, H. (1952). Portfolio Selection. *The Journal of Finance*, *7*(1), *77-91*.

Massimiliano C., & Michael M. (2013). Ten Things You Should Know about the Dynamic Conditional Correlation Representation. *Econometrics*, 1(1), 115-126.

Mehra R.a.P., Edward (1985). The equity premium: a puzzle, *Journal of Monetary Economics*, *15*(2), *145-161*.

Mishra, T. (2014). Dynamics of investors' risk aversion in emerging stock markets: Evidence from Saudi Arabia. SAMA Working Paper.

Myers R.J., & Thompson S.R. (1989). Generalized Optimal Hedge Ratio Estimation, *American Agricultural Economics Association*.

Pratt J.W. (1964). Risk Aversion in the Small and in the Large, *Econometrica*, *32*(1-2), *122-136.*

Sharpe W.F. (2007) Expected Utility Asset Allocation. *Financial Analysts Journal*, *63*,18-30.

Shrestha, K. (2009) Estimation of Market Risk Premium for Japan. *Enterprise Risk Management,1*(1).

Yang W. (2001). M-GARCH hedge ratios and hedging effectiveness in Australian futures markets Joondalup, Western Australia.

Yuan-Hung Hsu K., Ho-Chyuan C.,& Kuang-Hua C. (2007). On the application of the dynamic conditional correlation model in estimating optimal time-varying hedge ratios. *Applied Economics Letters, 14,* 503-509.

Appendix

Robustness Check

The research intends to ensure whether RAHR outperforms MVHR. To ensure that not only SET50 index futures outperform in RAHR but also other stocks. In this case, the research brings 10 stocks, classified by the biggest market capitalization in order to clearly compare the hedging performance between RAHR and MVHR. Correspondingly, result shows that RAHR achieves 5 performances such as high return, utility, Sharpe ratio, low optimal contract and hedging cost. The result corresponds to the main study that testing index market provides the same result as individual stocks while MVHR just achieves minimum variance and high hedge effectiveness.

Table A: Hedging performance between MVHR and RAHR of 10 individual stocks

= RAHR is achieved   = MVHR is achieved

Company	Return	Variance	Utility	Shape Ratio	Effectiveness	Opt Contract	Cost
PTT							
BANPU							
SCC							
LH							
QH							
KBANK							
SCB							
BBL							
KTB							
ADVANC							

Source: Author’s Calculation