



**Measuring Hedging Effectiveness of Stock
Index Futures by Using Simulation Approach:
Empirical Evidence of KOSPI 200
from 2003-2006**

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An Independent Study
Submitted in Partial Fulfillment of
the Requirement for the Degree of
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ABSTRACT

This paper focuses on hedging effectiveness of KOSPI 200 index futures which is measured by percentage reduction in variance of portfolio returns due to dynamic hedging. Random selection technique is employed in order to form large number of stock portfolios with different size (number of stocks contained in a portfolio). Simultaneously, these simulated portfolios are hedged by using ex-ante hedge ratios and actual performance of each portfolio is measured. The results show that hedging can effectively reduce the portfolio variance and the hedging effectiveness has a positive relationship with portfolio size. However, hedging effectiveness in 2005 is noticeably low as compared to other years due to low correlations in bullish period. For the hedge ratio estimation technique, Minimum Variance Hedge Ratio obtained from OLS estimation can generate highest hedging effectiveness from 2003 to 2006. Besides, annual returns, annual variance and worst weekly returns given 95% confidence level are also quantified.

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INTRODUCTION

Normally, objectives of entering futures market are divided into three major perspectives, namely hedging, speculative and arbitrage perspectives. At this point, my interesting is the hedging perspective which is the original demand for futures contract. Therefore, this paper will apply stock index futures in order to hedge against randomly selected stock portfolio with different portfolio size (i.e. number of stocks in a portfolio). If the selected stock portfolio and index futures are expected to move in the same direction and magnitude, hedging can be simply executed by taking a short position in index futures by the same amount as stock portfolio value without estimation of hedge ratio. However, hedgers need to estimate the hedge ratio since the relationship between stock portfolio returns and futures returns is directly dependent on the component stocks. This hedge ratio should represent the sensitivity of portfolio returns with respect to changes in futures price. Although using portfolio beta as a hedge ratio is very common for equity portfolio manager, this beta-hedged strategy implicitly ignores basis risks between spot and futures prices. Therefore, Minimum Variance Hedge Ratio (MVHR) was constructed in order to provide a better estimation of hedge ratio. It is directly derived from the objective of minimizing risk represented by expected portfolio variance.

In this paper, four hedge ratios are explored in terms of hedging effectiveness measured by percentage reduction in variance. These selected hedge ratios are naïve or traditional one-to-one, beta, MVHR and Exponentially Weighted Moving Average (EWMA). Typically, there are many variations in econometric methods for estimating the hedge ratio such as standard Ordinary Least Square (OLS), Error Correction Mechanism (ECM) and Generalized Autoregressive Conditional Heteroscedasticity (GARCH). This paper will employ OLS in order to estimate the hedge ratio with large number of simulations. Moreover, EWMA with a constant decay factor will be added for hedge ratio estimation. Many literatures [Holmes (1996), Copeland and Zhu (2005), Alexander and Barbosa (2006)] empirically show that the OLS can outperform those more advanced techniques.

From previous literatures, hedging effectiveness can be quantified ex-post (in-sample) and ex-ante (out-of-sample). In-sample test which measures the hedging effectiveness from the same data used in hedge ratio calculation is meaningless to practitioners since they cannot wait until the end of period and then hedge backward. In contrast, out-of-sample test is more realistic because hedge ratio is first estimated in the estimation period and then hedging effectiveness will be measure in the subsequent period (called hedge period). Thus, out-of-sample test will be applied in this paper. The main objective is to measure hedging effectiveness from naïve, beta, MVHR and EWMA hedge ratio that apply to equally weighted portfolio with 5, 10, 15, 20 and 25 stocks. The dataset contains weekly price of index, lead month index futures and constituents of KOSPI 200 (Korean) from 2001 to 2006. The EXCEL with Visual Basic Application (VBA) is created in order to explore the relationship between hedging effectiveness and portfolio size given different hedge ratio estimation. This model allows for changes in input data so that empirical results from interested market can be instantly tested. Therefore, hedging effectiveness of SET 50 of Thai market can be explored later when we have enough data.

LITERATURE REVIEW

Stock index futures contracts began the first trading on February 24, 1982, when the Kansas City Board of Trade introduced futures on the Value Line Index. Hedging provides a major justification for futures trading. It is therefore not surprising that the hedging effectiveness of stock index futures has been widely investigated.

Most of studies before 90s focus on the ex-post hedging effectiveness of stock index futures contracts [Figlewski (1984), Junkus and Lee (1985) and Graham and Jennings (1987)], while a little attention has been given to the ex-ante hedging effectiveness. Ex-post estimation implicitly assumes that hedgers have perfect foresight with respect to spot and futures prices and can thus estimate the optimal (risk minimizing) hedge ratio for the coming period, or that the relationship between these prices is constant. In practice, hedgers do not have perfect foresight and optimal hedge ratios change over time. Consequently, previous studies may overestimate hedging effectiveness. Actually, hedging effectiveness from ex-post estimation is just the coefficient of determination (R^2) when futures returns is independent variable and cash returns is dependent variable. Figlewski (1984) studies the hedging effectiveness of S&P 500 index futures contracts during June 1982 - September 1983 and observes that almost 80% of risks can be eliminated from ex-post MVHR hedge ratio and MVHR provide higher effectiveness than beta-hedge strategy. After Figlewski (1984), Junkus and Lee (1985) and Graham and Jennings (1987) have also examined the hedging effectiveness of MVHR hedge ratio. Although their periods of study and markets are different, the results strongly show that more than half of the total risks are condensed by using MVHR hedge ratio and MVHR still outperforms the beta hedging strategy.

Holmes (1995) examines the ex-ante hedging effectiveness of FTSE 100 index futures contracts using data over the period 1984-1992 and found that 80% of risks can be removed. A year after that, Holmes (1996) employs more advanced econometric techniques such as an Error Correction Model (ECM) and the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) approach in order to estimate the MVHR hedge ratio with the same data used in Holmes (1995).

Surprisingly, Holmes (1996) shows that the standard OLS estimation outperforms a strategy where the MVHR is estimated by those more advanced econometric techniques. More surprisingly, almost ten years after Holmes (1996), his finding is still consistent with Copeland and Zhu (2005) who also utilize the standard OLS, ECM and GARCH approach to evaluate the hedging effectiveness of six major index futures markets (Australia, Germany, Japan, Korea, UK and USA) during 1995-2005. The results suggest that “although (in principle) the more sophisticated model should provide more accurate estimates of the true underlying parameter values, in practice the benefit is likely to be very small or even negative”. This finding is also in line with Alexander and Barbosa (2006) who study hedging effectiveness of selected markets in North America, South America, Europe and Asia. They conclude that there is no evidence to support that GARCH can outperform OLS in estimating hedge ratio. In addition, they suggest that advanced electronic trading platforms and highly liquid Exchange Traded Funds (ETF) trading cause the hedging effectiveness of naïve strategy to be close to those obtained from econometric model.

More importantly, most models discussed above examine the hedging effectiveness of portfolio whose cash position is an index (index portfolio) rather than typical stock portfolio (non-index portfolio) which consists of relatively small number of stocks. Graham and Jennings (1987) is the first one who breaks this mold by using the random selection technique to generate 90 portfolios which consist of only 10 stocks. The results show that stock index futures are less than half as effective at hedging non-index portfolios as they are at hedging cash indexes. Although MVHR still outperforms beta-hedged, the gap between these two hedging strategies is very narrow for stock portfolio with low systematic risk or beta. Rather than using the random selection, Holmes and Butterworth (2001) apply the non-index hedging when the cash portfolios are professionally managed portfolios or mutual funds. The results show that hedging effectiveness is relatively poor compared to index portfolio hedging.

For the measurements of hedging effectiveness, Brailsford, Corrigan and Heaney (2000) have reviewed several major hedging effectiveness measurements (such as reduction in volatility and increase in returns) and make an empirical comparison among those measurements by applying to the Australian market during

1990 to 1999. The results indicate that the selection of hedging effectiveness measurement has a significant impact on the hedged portfolios.

In my study, the cash portfolio is a typical stock portfolio which is randomly generated from all stocks that are constituents of the selected index. Unlike Graham and Jennings (1987) who are the first one to employ this technique with 10-stock portfolio, I will apply this random technique to five portfolio sizes which are 5, 10, 15, 20 and 25 stocks in order to explore the impact of portfolio size on the hedging effectiveness. For the econometric technique to estimate the hedge ratio, the standard OLS will be used since it is proven by many studies [Holmes (1996), Copeland and Zhu (2005) and Alexander and Barbosa (2006)] that it can perform as good as other more advanced techniques such as ECM and GARCH. However, the EWMA specification will be added to estimation of hedge ratio in order to explore the basic model that employs conditional variance concept. Lastly, I decide to measure the ex-ante hedging effectiveness by the percentage reduction in variance of the hedged portfolio compared to the unhedged portfolio.

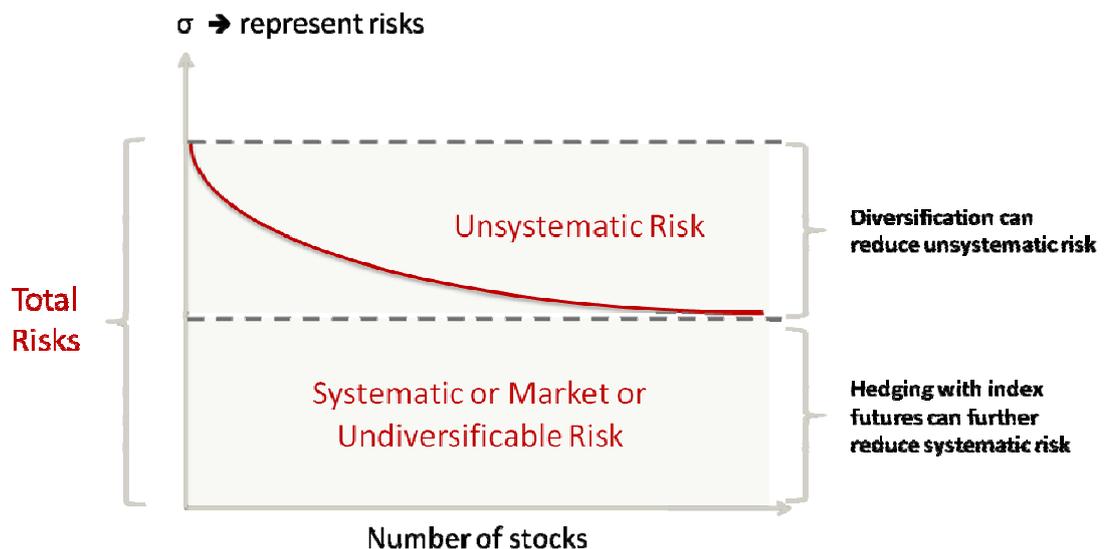
THEORETICAL FRAMEWORK

First, the concept of investment risks and diversification will be introduced. Then, the use of stock index futures as a hedging instrument will be explained. After that, selected hedge ratio estimation techniques will be introduced. Last, the measurements of hedging effectiveness which take into account both risk and returns will be discussed.

Risk and Portfolio Diversification

As a foundation of investment science, Markowitz (1959) measures investment risk by standard deviation of the returns. Although it relies on the ambiguous assumption that returns have to be normally distributed, this risk measurement has been widely used by both academics and practitioners. Combined with the assumption that rationale investor is risk averse, the investor will always prefer portfolio that provide lower expected standard deviation given the identical level of expected returns.

FIGURE1: Unsystematic and Systematic Risks



Portfolio risk can be reduced by adding more securities into the portfolio (as long as the correlation coefficient between existing portfolio returns and that additional security is less than 1). This is the concept of diversification and most investors perceive it as one of the most important factor in forming the appropriate

portfolio. The lower the correlation, the more benefits investor can get from diversification. However, in the stock market without short selling, most stocks tend to be co-move (or have positive correlation) to each other and to the market, therefore, diversification benefit is limited. As shown in the graph, only unsystematic risk can be diversified away and the investor has to face systematic risk or market risk. This paper will focus on hedging with stock index futures which is currently available in many Asian financial markets in order to reduce the systematic or market risk. Next part, the objective and basic intuition of using stock index futures to hedge current stock positions will be studied for more details.

Hedging with Stock Index Futures

Stock index futures is the security whose returns is highly correlated with the market or index because the index is used as the underlying asset of the futures contract. Since the individual stock tend to be co-move to the market or index, selling stock index futures contract will generate returns that is negatively correlated to the cash portfolio. By doing this, the systematic or undiversifiable risk can now be condensed. Initially, this concept seems to be very easy but the problem is that how many futures contracts we should sell. Consequently, hedge ratio (h) has to be estimated. In this paper, estimated hedge ratio will be used as a multiplier for the short position in index futures. In addition, for hedgers or other practitioners, this parameter will be used for determining how many futures contracts to sell in order to hedge the current cash portfolio which is the stock position in this context. Number of futures contracts to be sold is determined by the following formula

$$N = (h * P) / A$$

where N: number of futures contracts

h: hedge ratio

P: Value of cash portfolio

A: Value of one futures contract

For numerical example, suppose that a fund manager currently holds a stock portfolio worth 100 million baht and he estimates his appropriate hedge ratio to be 1.5. How many SET 50 index futures should he sell in order to minimize the risk given the futures price of 500 with the multiplier of 1,000?

Calculation → $h = 1.5$ and $P = 100,000,000$ and $A = 500 * 1,000$

$$N = (1.5 * 100,000,000) / (500 * 1,000)$$

$$N = 300 \text{ contracts}$$

From the above calculations, it means that this fund manager needs to take a short position of 300 contracts of SET 50 index futures in order to performing the hedging against movement in SET 50 index. Although the process seems to be relatively simple, the acquiring of hedge ratio (h) is quite problematic. Therefore, next issue will introduce how to estimate this hedge ratio.

Hedge Ratio Estimation

Basically, hedge ratio that aims to reduce portfolio variance can be estimated by three major concepts which are the traditional one-to-one hedge, beta-hedged and Minimum Variance Hedge Ratio (MVHR). The one-to-one or naïve hedge ratio is very simple since it assumes that portfolio returns and returns from futures contract will exactly move in the same direction and magnitude. Therefore, the naïve hedge ratio is always equal to one. If returns from futures contract exactly match the portfolio returns, this simple hedging strategy is enough to eliminate price risk. Since the sensitivity of portfolio returns given a small change in index or futures often deviates from unity, the statistical techniques are required in order to provide a better estimation of hedge ratio. Generally, these techniques are known as beta-hedged and Minimum Variance Hedge Ratio (MVHR). Traders and retail investors might be more familiar with the beta since it is a famous risk factor in equity investment. Therefore, portfolio beta can be used as a quick estimation of hedge ratio. Considered as an implication from CAPM, hedge ratio is exactly the beta of a stock portfolio since it will drive total portfolio beta equal to zero. Portfolio with zero beta is expected to be insensitive to changes in market returns. The beta is a slope coefficient of the OLS regression model where independent variable is market returns and dependent variable is stock portfolio returns.

$$R_s = \alpha + \beta R_m + \varepsilon$$

Beta coefficient or estimated slope from above regression model is

$$h = \beta = \text{Cov}(R_s, R_m) / \text{Var}(R_m)$$

where h: hedge ratio

β : portfolio beta

R_s : returns on stock portfolio

R_m : returns on market portfolio

In practice, portfolio beta can be calculated as the weighted average of individual stock beta. Therefore, hedger might employ those published stock beta in order to get a quick estimation of hedge ratio of a portfolio. However, using beta as a hedge ratio implies that there is no basis risk or spread between underlying index and futures. However, the volatility of futures price is consistently higher than the volatility of the underlying index. Therefore, using beta as a hedge ratio will lead to the over-hedged portfolio. This basis risk is taken into consideration by the MVHR. Therefore, MVHR is theoretically a better hedge ratio since it is estimated from portfolio returns and returns from futures position instead of index returns.

The MVHR model has been originally proposed by Johnson (1960) and developed further for stock index futures by Ederington (1979). Key assumption of MVHR is that investor is extremely risk averse so that he will sacrifice large amount of expected returns in exchange from very small reduction in risks. In other words, he will always prefer portfolio with the minimum level of risk. Therefore, hedge ratio can be derived from the following optimization.

$$R_p = R_s - hR_f$$

$$\text{OBJ: Min}_h[\text{Var}(R_p)] = \text{Var}(R_s) + h^2\text{Var}(R_f) - 2h\text{Cov}(R_s, R_f)$$

$$\text{FOC: } 2h\text{Var}(R_f) - 2\text{Cov}(R_s, R_f) = 0$$

$$h = \text{Cov}(R_s, R_f) / \text{Var}(R_f)$$

where R_p : returns on hedged portfolio

R_s : returns on stock portfolio

R_f : returns on futures position

h: hedge ratio

According to MVHR, optimal hedge ratio can be obtained from the variance and covariance estimation which is one of the most important research fields in finance. Instead of standard formula for unconditional variance and covariance, EWMA will be employed in order to estimate the MVHR. Exponentially Weighted Moving Average (EWMA) is a method of predicting conditional future volatility whose concept is to assign more weights on recent observations through the value of decay factor (λ). The lower the λ , the more weight is assigned to recent market movement.

$$\sigma_t^2 = \lambda \sigma_{t-1}^2 + (1 - \lambda) u_{t-1}^2$$

$$u_t = \ln \left(\frac{P_t}{P_{t-1}} \right)$$

where σ_t^2 : estimated variance at time t

λ : decay factor ($0 < \lambda < 1$)

P_t : price level at time t

EWMA with the decay factor of 0.94 is very popular in practice since it is being used in J.P. Morgan's RiskMetrics database. Therefore, the EWMA with the decay factor of 0.94 will be used in order to estimate variance of futures, covariance between futures and stock portfolio and finally the hedge ratio. Actually, EWMA is a special case of GARCH(1,1) model proposed by Bollerslev (1986) as follows

$$\sigma_t^2 = \gamma V_L + \alpha u_{t-1}^2 + \beta \sigma_{t-1}^2$$

$$\gamma + \alpha + \beta = 1$$

$$u_t = \ln \left(\frac{P_t}{P_{t-1}} \right)$$

where σ_t^2 : estimated variance at time t

V_L : long-term variance

P_t : price level at time t

EWMA can be presented in the GARCH(1,1) form when $\gamma = 0$, $\alpha = (1 - \lambda)$ and $\beta = \lambda$. In other words, EWMA puts no weight on long-term variance in predicting future variance. It cares only estimated variance and recent shocks.

The following issue after implementing hedging strategy is how to quantify that effectiveness. Therefore, next section will introduce some hedging effectiveness measurements which incorporate not only reduced risks but also changing in risk adjusted returns.

Hedging Effectiveness Measurement

According to Markowitz (1959), standard deviation is considered as a proxy of investment risks. Therefore, the primitive measurement for hedging effectiveness is the percentage reduction in variance of portfolio returns.

$$HE = (\sigma_u - \sigma_h) / \sigma_u$$

where σ_u : standard deviation of unhedged portfolio

σ_h : standard deviation of hedged portfolio

However, the shortcoming of this measurement is that it relies solely on risk reduction and suggests nothing about changes in returns. Therefore, Howard and D'Antonio (1987) introduce new measure of hedging effectiveness that take into account both risks and returns. They construct this measurement based on Sharpe ratio

$$HE = \theta_h - \theta_u$$

$$\theta_i = (R_i - R_{free}) / \sigma_i$$

where θ_h : sharpe ratio of hedged portfolio

θ_u : sharpe ratio of unhedged portfolio

θ_i : sharpe ratio of portfolio i

R_i : portfolio returns

R_{free} : risk-free rate or riskless returns

σ_i : portfolio standard deviation

Although Sharpe ratio seems to be the sensible measurement, it is inappropriate to measure the hedging effectiveness because it is usually problematic to compare the negative Sharpe ratio from two different portfolios. For example, if two portfolios yield the same level of negative excess returns but different volatility, high volatility portfolio will generate greater Sharpe ratio than the low volatility

portfolio. Obviously, it is contradict to the traditional mean-variance analysis. In fact, Sharpe ratio is just the probability to get higher-than-riskless-returns under the normal distribution. Therefore, I decide to ignore this hedging effectiveness measurement and employ measurements that truly focus on the variance reduction. Besides percentage reduction in variance of portfolio returns, actual 95% worst returns from weekly interval will be explored since investor is more aware of downside risk. The average returns will also be quantified in order to explore a trade-off from reducing risks.

DATA AND METHODOLOGY

The dataset consists of weekly price series from 2001 to 2006 of underlying index, futures and all constituents of KOSPI 200. Korean derivatives market is considered as one of the biggest derivatives exchange of the world in terms of trading value. KOSPI 200 index is selected since it has been widely used as an underlying for futures and options. It contains 200 blue-ship stocks traded in KRX with base index and base year of 100 and 1990, respectively. However, 169 constituents of KOSPI200 are selected since the sample stock has to be included in KOSPI 200 as of 31 December, 2006 and its listing date is prior to 1 January, 2001. Hedge ratio from each technique is estimated from weekly continuous returns according to the previously discussed formulas. The first two year of dataset is used to estimate variance, covariance and hedge ratio. Therefore, the hedging period will start from the beginning of 2003 and stop at the end of 2006. Five sets of portfolio based on their hedge ratios which are unhedged, naïve, beta, MVHR and EWMA will be constructed.

TABLE1: Hedge Ratio Estimation of each Portfolio

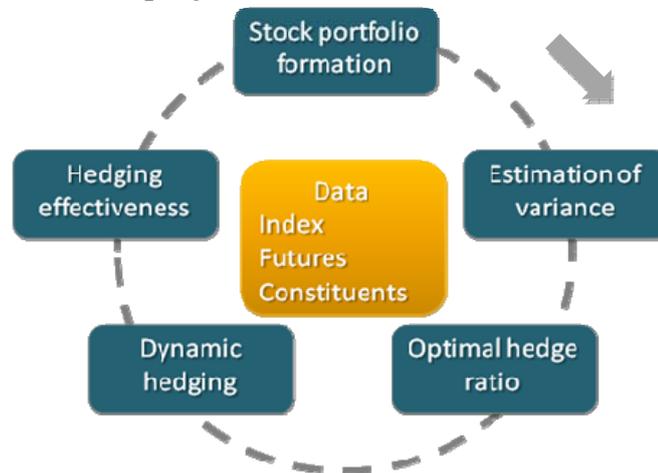
Portfolio	Hedge Ratio Estimation
Unhedged	There is no hedge ratio or hedge ratio is always zero.
Naïve	Hedge ratio is constant with the value of one.
Beta	Hedge ratio is the portfolio beta from market model.
MVHR	Hedge ratio is the slope coefficient of regression portfolio returns with returns from index futures
EWMA	EWMA with the decay factor of 0.94 will be used and the first prediction of variance is the unconditional variance from 2001-2002 data.

Suppose that the first equally-weighted portfolio of 5 stocks is randomly selected at the beginning of 2003. The optimal hedge ratio from each technique from estimated variance and covariance is calculated. Then, short position in index futures will be executed according to the hedge ratio. A week later, new hedge ratio will be

estimated according to recent market data so that both portfolio weights and futures position will be rebalanced. Note that EWMA hedge ratio is generally more fluctuated than MVHR and beta hedge ratio since this conditional variance will give more weights on recent shocks. In addition, MVHR strategy will consistently provide higher hedge ratio compared to the beta-hedged strategy.

Repeatedly, dynamic hedging will be performed as time passes and portfolio returns on the weekly interval will be measured until the end of 2006. After obtaining returns from each portfolio, variance and hedging effectiveness for each year will be quantified.

FIGURE2: Simulation Looping



After finishing the above loop, the simulation technique will be utilized in order to randomly select 10,000 portfolios and repeat the above procedure. The system will record mean value of hedging effectiveness of each year from the simulation. Besides hedging effectiveness, average weekly returns, variance and actual 95% worst returns will be explored. Hedging effectiveness is expected to have a positive relationship with the number of stocks in a portfolio for all hedge ratio estimation technique. In addition, MVHR is expected to generate higher effectiveness than beta-hedging and naïve portfolio. In order to test those statements, I have designed an Excel file with VBA to deal with simulation. Once all required dataset is plugged-in, users can specify number of stocks in a portfolio and number of iterations. The result table will provide the mean value and standard error of hedging effectiveness for each portfolio plus some additional statistics.

EMPIRICAL RESULTS

In this part, the analysis of results mainly focuses on average value of hedging effectiveness. The numbers of each year and overall period (2003-2006) will be presented for each combination of portfolio size and hedge ratio estimation technique. In addition, other statistics such as annual variance, annual returns and worst weekly returns given 95% confidence level are also presented at the end.

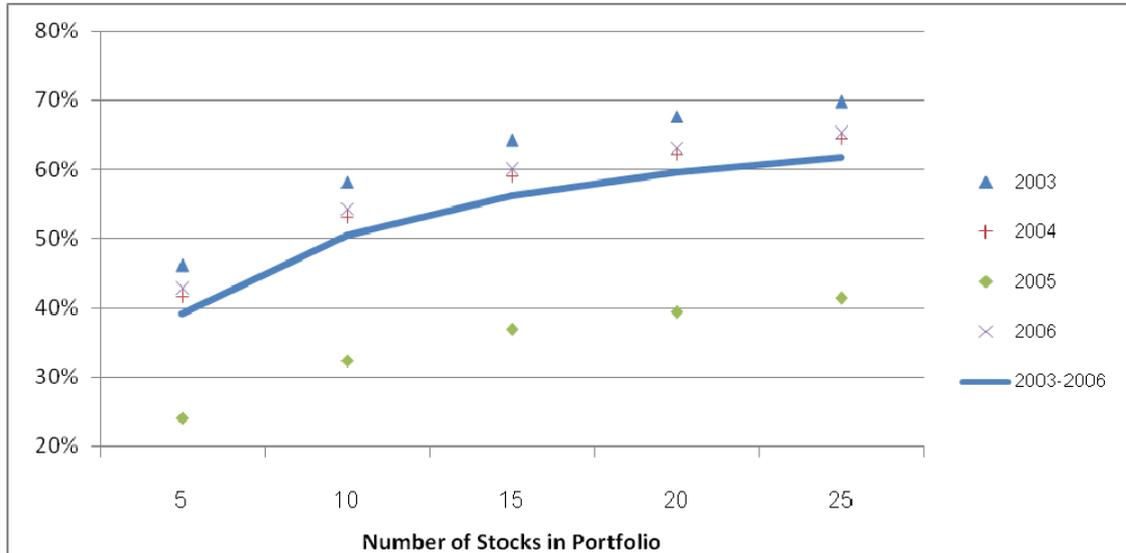
TABLE2: Hedging Effectiveness

Year	Portfolio	Number of Stocks in Portfolio				
		5	10	15	20	25
2003	Naïve	40.8802%	53.8342%	60.1720%	63.8252%	66.0815%
	Beta	45.7598%	57.7876%	63.8065%	67.2579%	69.3645%
	MVHR	46.0885%	58.1585%	64.1983%	67.6587%	69.7694%
	EWMA	46.4392%	58.6067%	64.6777%	68.1988%	70.3212%
2004	Naïve	36.1957%	47.4363%	53.3717%	56.4785%	58.6912%
	Beta	41.0081%	52.3846%	58.3406%	61.5300%	63.7738%
	MVHR	41.5310%	53.0004%	58.9788%	62.1890%	64.4490%
	EWMA	41.3889%	53.1296%	59.1989%	62.4996%	64.8157%
2005	Naïve	21.5452%	29.7342%	34.2921%	36.8117%	38.8937%
	Beta	23.7217%	32.0001%	36.5536%	39.0993%	41.1557%
	MVHR	24.0675%	32.3162%	36.8438%	39.3717%	41.4106%
	EWMA	23.3873%	31.6587%	36.2510%	38.8026%	40.8284%
2006	Naïve	41.2341%	52.9081%	58.5990%	61.7208%	63.8581%
	Beta	42.5678%	54.2959%	60.0016%	63.1703%	65.2845%
	MVHR	42.7156%	54.3242%	59.9807%	63.1157%	65.2038%
	EWMA	41.5032%	53.1578%	58.9013%	62.0332%	64.1533%
2003-2006	Naïve	36.2312%	47.5203%	53.2965%	56.4736%	58.6937%
	Beta	38.8488%	50.2010%	56.0152%	59.2470%	61.4660%
	MVHR	39.0719%	50.4472%	56.2701%	59.5082%	61.7295%
	EWMA	38.6909%	50.2135%	56.1203%	59.4135%	61.6639%

Hedging effectiveness which is measured by reduction in portfolio variance for each combination of portfolio size and hedge ratio estimation is changed from time to time. As seen from TABLE2 and FIGURE3, year 2005 provide awfully low hedging effectiveness while the numbers of other years are fairly close. The year 2005 is obviously the bull period since average returns of simulated portfolio is more than 50%. Probable explanation is that correlations among individual stocks usually declines during the bull market, therefore, index futures has less power to track changes in stock portfolio returns. In contrast, correlation usually increases during the

bear period. In the extreme or stress event when the market crashes, correlation tends to move closer to one and hedging effectiveness is expected to be noticeably high.

FIGURE3: Hedging Effectiveness of MVHR Portfolio

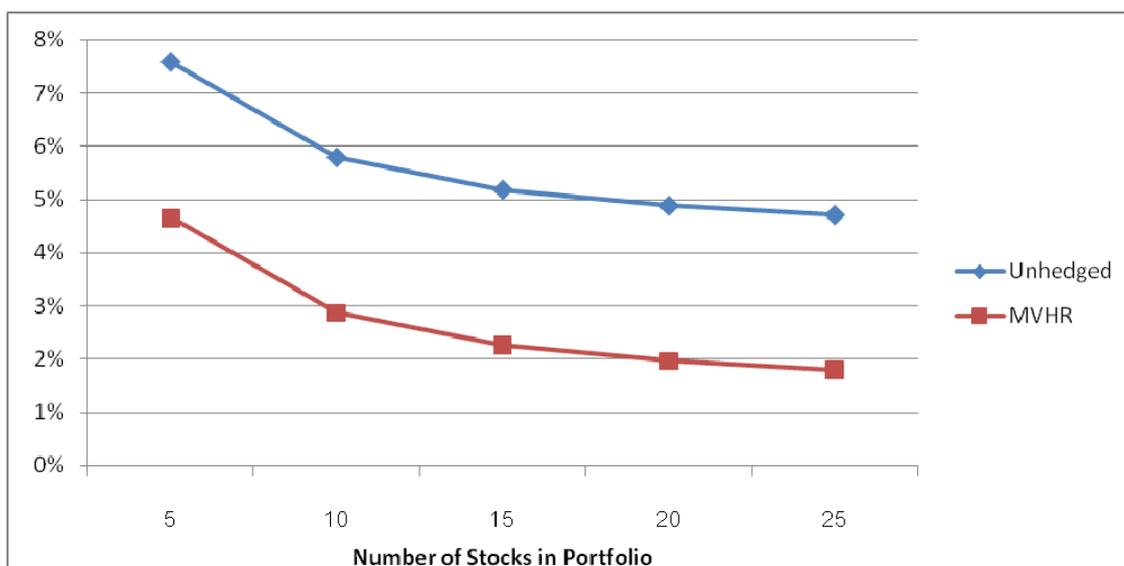


Obviously seen from FIGURE3, hedging effectiveness has a strong positive relationship with portfolio size or number of stocks in a portfolio but the marginal effectiveness is decreasing when we add more stocks. For example, from TABLE2, hedging effectiveness of MVHR portfolio in 2003 increases from 46.0085% to 58.1585% (or 12.0700% in absolute term) if the portfolio size changes from 5 to 10 stocks. If we increase number of stocks further from 10 to 15, hedging effectiveness will increase by 6.0397%.

For the comparison of hedge ratio estimation, naïve portfolio provides noticeably lower effectiveness than other techniques. In other words, variance of naïve portfolio is always higher than beta, MVHR and EWMA portfolio, especially in 2003 and 2004. Nevertheless, the margins (hedging effectiveness of beta, MVHR and EWMA over naïve portfolio) are very narrow in 2005 and 2006 since the estimated hedge ratios of beta, MVHR and EWMA portfolio move closer to one. This is due to the fact that variance of the index and futures, which is the denominator of hedge ratio, is substantially reduced. The annual variance of futures returns in 2001 and 2002 is approximately 12% and the number is reduced to 6% in 2003.

Since the hedging effectiveness of beta, MVHR and EWMA portfolio are very close, using beta as a hedge ratio might be enough in order to reduce portfolio variance. The more advanced technique EWMA can outperform MVHR in 2003 and 2004 since it has superior feature to capture dramatic reduction in variance of futures from 2001 and 2002.

FIGURE4: Annual Variance of Unhedged and MVHR Portfolio from 2003-2006



There are two essential points contained in FIGURE4 which represents the average annual variance from 2003-2006 of unhedged and MVHR portfolio. The first one is that investment risk measured by portfolio variance has a negative relationship with number of stocks. The second point is that hedging with stock index futures can effectively reduce the risk by shifting down the variance for all portfolio size by approximately 3%. This constant absolute reduction in variance provide the positive relationship between portfolio size and hedging effectiveness as measured by percentage reduction in portfolio variance.

TABLE3 can represent diversification and hedging benefits. Diversification can be achieved by adding more stocks into a portfolio in order to reduce portfolio variance. However, this diversification benefit directly depends on correlations among individual stocks. The higher the correlation, the lower diversification benefit and vice versa. On the other side, hedging benefit refers to the reduction in variance of hedged portfolio when compared to unhedged portfolio given the same number of

stocks in a portfolio. This hedging benefit can be quantified by the ex-ante hedging effectiveness which is the percentage reduction in variance of portfolio returns for out-of-sample observations. The hedging effectiveness also depends on correlations among individual stocks. Higher correlation makes stock portfolio and index futures to move closely together. Therefore, hedging effectiveness is relatively high when the correlation is high and vice versa.

TABLE3: Annual Variance

Year	Hedge Ratio	Number of Stocks in Portfolio				
		5	10	15	20	25
2003	Unhedged	9.2345%	7.2306%	6.5371%	6.1855%	5.9992%
	Naïve	5.2675%	3.2246%	2.5270%	2.1822%	1.9916%
	Beta	5.0098%	3.0302%	2.3498%	2.0138%	1.8293%
	MVHR	4.9879%	3.0080%	2.3274%	1.9914%	1.8069%
	EWMA	4.9668%	2.9805%	2.2996%	1.9611%	1.7764%
2004	Unhedged	7.5848%	5.8985%	5.3267%	5.0351%	4.8652%
	Naïve	4.6994%	3.0046%	2.4171%	2.1426%	1.9693%
	Beta	4.4532%	2.7742%	2.1935%	1.9187%	1.7470%
	MVHR	4.4180%	2.7406%	2.1613%	1.8869%	1.7153%
	EWMA	4.4471%	2.7436%	2.1561%	1.8763%	1.7017%
2005	Unhedged	7.3147%	5.1669%	4.4578%	4.1274%	3.9208%
	Naïve	5.7927%	3.6502%	2.9335%	2.6083%	2.3951%
	Beta	5.7219%	3.5758%	2.8604%	2.5341%	2.3216%
	MVHR	5.7092%	3.5658%	2.8517%	2.5260%	2.3140%
	EWMA	5.7597%	3.5998%	2.8783%	2.5496%	2.3369%
2006	Unhedged	6.1495%	4.8231%	4.3764%	4.1447%	4.0203%
	Naïve	3.6010%	2.2555%	1.7999%	1.5790%	1.4479%
	Beta	3.5528%	2.2067%	1.7515%	1.5287%	1.3982%
	MVHR	3.5489%	2.2086%	1.7550%	1.5329%	1.4031%
	EWMA	3.6237%	2.2647%	1.8020%	1.5776%	1.4451%
2003-2006	Unhedged	7.5824%	5.7911%	5.1849%	4.8840%	4.7120%
	Naïve	4.8243%	3.0175%	2.4032%	2.1116%	1.9345%
	Beta	4.6765%	2.8877%	2.2794%	1.9890%	1.8141%
	MVHR	4.6599%	2.8736%	2.2662%	1.9763%	1.8017%
	EWMA	4.6899%	2.8877%	2.2744%	1.9814%	1.8052%

Year 2005 is a good example for the relationship between portfolio size, diversification benefit and hedging effectiveness. Low correlation during this bull period increase the diversification benefit but lessen the hedging effectiveness. This can be numerically explained by comparing year 2005 with year 2004. The variance of 5-stock unhedged portfolio in these two periods are very close but diversification can drive variance of 25-stock portfolio to 4.8652% and 3.9208% in 2004 and 2005, respectively. However, the variance of hedged portfolio in 2005 is relatively close to

the variance of unhedged portfolio. Although the main objective for this paper is to examine hedging effectiveness based on reduction in variance, other statistics are also presented. They are average annual returns and worst weekly returns.

According to TABLE3 and TABLE4, MVHR is the best hedging strategy since it can provide the least average variance with the highest average returns from 2003-2006. In other words, we can conclude that the MVHR is the most efficient hedging portfolio according to the mean-variance analysis. This average annual returns of each portfolio is constant for all portfolio sizes. The average annual returns of unhedged portfolio is approximately 23%. If the MVHR hedging strategy is employed, the returns is reduced to approximately 7%. This fall in returns is compenstaed by reduction in variance.

TABLE4: Annual Returns

Year	Hedge Ratio	Number of Stocks in Portfolio				
		5	10	15	20	25
2003	Unhedged	24.6856%	24.7996%	24.7456%	24.7707%	24.7548%
	Naïve	2.8614%	2.9755%	2.9215%	2.9465%	2.9306%
	Beta	4.4473%	4.5153%	4.4545%	4.4798%	4.4649%
	MVHR	5.0437%	5.1137%	5.0541%	5.0789%	5.0635%
	EWMA	7.4944%	7.5167%	7.4362%	7.4877%	7.4466%
2004	Unhedged	12.6086%	12.7773%	12.7957%	12.6980%	12.7927%
	Naïve	5.4400%	5.6087%	5.6271%	5.5294%	5.6241%
	Beta	6.7378%	6.9041%	6.9159%	6.8207%	6.9085%
	MVHR	6.9850%	7.1558%	7.1659%	7.0698%	7.1587%
	EWMA	4.7741%	4.9799%	5.0034%	4.9142%	4.9986%
2005	Unhedged	51.8109%	51.9717%	51.7832%	51.8552%	51.9671%
	Naïve	8.3590%	8.5197%	8.3313%	8.4032%	8.5152%
	Beta	15.5589%	15.6671%	15.4412%	15.5535%	15.6457%
	MVHR	17.7457%	17.8766%	17.6378%	17.7512%	17.8474%
	EWMA	15.4595%	15.6519%	15.4348%	15.5390%	15.6228%
2006	Unhedged	3.3247%	3.2767%	3.5682%	3.4077%	3.5103%
	Naïve	-2.3518%	-2.3998%	-2.1083%	-2.2688%	-2.1662%
	Beta	-1.9652%	-2.0337%	-1.7471%	-1.9005%	-1.8065%
	MVHR	-1.5588%	-1.6264%	-1.3408%	-1.4945%	-1.3996%
	EWMA	-2.6089%	-2.7029%	-2.4112%	-2.5727%	-2.4865%
2003-2006	Unhedged	23.1150%	23.2139%	23.2305%	23.1905%	23.2634%
	Naïve	3.5737%	3.6727%	3.6892%	3.6492%	3.7221%
	Beta	6.1863%	6.2549%	6.2575%	6.2300%	6.2944%
	MVHR	7.0443%	7.1203%	7.1193%	7.0916%	7.1574%
	EWMA	6.2856%	6.3669%	6.3709%	6.3475%	6.4004%

According to the Markowitz's portfolio theory, risk can be measured by variance if the stock returns experience the normal distribution. However, the fat tail usually occurs in the real world. Therefore, the worst weekly returns over 95% confidence level of each portfolio is also measured in order to explore the impact of hedging from different perspective. This approach is closely linked with the concept of Value at Risk (VaR) estimated by historical simulation method. Similar to the variance measurement, this worst weekly returns has a positive relationship with portfolio sizes. In other words, we can expect the improvement in worst returns (smaller loss in absolute terms) if we diversify by adding more stocks into a portfolio. However, the diversification benefit as measured by improvement in worst weekly loss is noticeably different for the hedged and unhedged portfolio. The diversification benefit of unhedged portfolio from this perspectives is relatively small. As seen from TABLE5, worst weekly returns of 5-stock unhedged portfolio is -5.7941% and the figure of 25-stock unhedged portfolio is improved by small amount to the level of -5.0443%. In contrast, weekly returns of 5-stock MVHR portfolio is -4.3697% and it is noticeably enhanced to the level of -2.8699% for 25-stock MVHR portfolio. For the effect of hedge ratio estimation, the results are quite similar to variance measurement since the worst weekly returns of beta, MVHR and EWMA portfolio are very close and they can noticeably outperform the naïve portfolio.

TABLE5: Worst Weekly Returns (95% confidence level)

Year	Portfolio	Number of Stocks in Portfolio				
		5	10	15	20	25
2003	Unhedged	-6.1403%	-5.7377%	-5.6329%	-5.6382%	-5.6441%
	Naïve	-4.6017%	-3.6884%	-3.2932%	-3.0877%	-2.9570%
	Beta	-4.4245%	-3.5350%	-3.1476%	-2.9482%	-2.8255%
	MVHR	-4.3958%	-3.5035%	-3.1130%	-2.9137%	-2.7905%
	EWMA	-4.3294%	-3.4236%	-3.0260%	-2.8149%	-2.6830%
2004	Unhedged	-5.5410%	-4.9189%	-4.6821%	-4.5691%	-4.5012%
	Naïve	-4.3300%	-3.5400%	-3.2113%	-3.0556%	-2.9462%
	Beta	-4.1550%	-3.3692%	-3.0440%	-2.8877%	-2.7749%
	MVHR	-4.1327%	-3.3433%	-3.0177%	-2.8607%	-2.7479%
	EWMA	-4.1862%	-3.3506%	-2.9959%	-2.8149%	-2.6752%
2005	Unhedged	-4.7496%	-4.2450%	-4.0586%	-3.9831%	-3.8878%
	Naïve	-4.5827%	-3.8547%	-3.5566%	-3.4189%	-3.3044%
	Beta	-4.3973%	-3.6596%	-3.3520%	-3.2048%	-3.0848%
	MVHR	-4.3447%	-3.6059%	-3.2979%	-3.1472%	-3.0263%
	EWMA	-4.4217%	-3.6661%	-3.3525%	-3.1998%	-3.0719%
2006	Unhedged	-5.6612%	-5.2188%	-5.0483%	-4.9582%	-4.9193%
	Naïve	-3.9327%	-3.1330%	-2.7619%	-2.5543%	-2.4132%
	Beta	-3.9033%	-3.0885%	-2.6970%	-2.4680%	-2.3160%
	MVHR	-3.9044%	-3.0901%	-2.6891%	-2.4451%	-2.2864%
	EWMA	-3.9932%	-3.1787%	-2.7670%	-2.5222%	-2.3569%
2003-2006	Unhedged	-5.7941%	-5.3065%	-5.1373%	-5.0786%	-5.0443%
	Naïve	-4.5398%	-3.7194%	-3.3653%	-3.1883%	-3.0614%
	Beta	-4.3954%	-3.5714%	-3.2139%	-3.0300%	-2.9026%
	MVHR	-4.3697%	-3.5443%	-3.1863%	-2.9980%	-2.8699%
	EWMA	-4.4075%	-3.5637%	-3.1864%	-2.9822%	-2.8395%

TABLE5 introduces another perspective of risk measurement that intendedly emphasis on downside risk. This measurement can be quantified by worst weekly returns given 95% confidence level. More precisely, the returns of each portfolio is ranked and the 5th percentile is selected. The results show that hedging with index futures is also effective under this downside risk measurement since the worst weekly returns of hedged portfolio is substantially better than the unhedged portfolio. Similar to the hedging effectiveness, year 2005 is the least effective since there is little improvement of worst weekly returns from hedging.

Although variance and the worst weekly returns can be used as risk measurement, the empirical difference between these two measures is the corresponding diversification benefit. Under the variance measurement, diversification benefit of unhedged and hedged portfolio is almost identical (as seen from FIGURE4 which displays the parallelness between two lines). However, under

the worst weekly returns measurement, diversification benefit of unhedged portfolio is relatively small compared to the diversification benefit of hedged portfolio. For numerical explanation, the 5-stock unhedged portfolio has a worst weekly returns during 2003-2006 of -5.7941% and this number is improved to -5.0443% for 25-stock unhedged portfolio. For MVHR, 5-stock portfolio has a worst weekly returns of -4.3697% and it is largely improved to the value of -2.8699% for 25-stock portfolio.

APPLICATIONS

This paper aims to provide contributions to both practitioners and academics who are interested in hedging with stock index futures. For practitioners, the empirical results of KOSPI 200 from 2003-2006 can be used as a stronger evidence to support their hedging decision making. According to empirical results, MVHR is generally recommended for fund manager who would like to protect his stock portfolio returns by using stock index futures since it can provide lowest variance over the specified market and period of study. However, this MVHR should be replaced by EWMA hedge ratio when there is a large change in variance since EWMA is assigned to put more weights on recent observations. In order to support this suggestion, the empirical results show that EWMA can outperform MVHR for all portfolio sizes in 2003 since the market variance is substantially reduced as compared with the numbers in 2001 and 2002. If the EWMA is implemented, it is strongly recommended for hedger to optimize the value of decay factor in order to reduce the model risks. Moreover, sophisticated hedger may employ GARCH technique which is theoretically superior to EWMA. Nevertheless, hedger should keep in mind that the GARCH family is likely to provide more variability in hedge ratio so that higher transaction costs will occur in order to rebalance portfolio. Hedging with index futures is expected to be less effective in the bull market since the correlations among stocks are relatively low. Therefore, diversification should play an important role of risk reduction during the bull period. Hopefully, these findings and suggestions are consistent to other markets and other different time period.

In order to have a stronger support for above recommendations, interested person can apply this simulation process to other financial markets. Actually, the constructed EXCEL VBA file can be applied to other selected financial markets with little modification depending on number of years of study. For Thai Futures Exchange (TFEX), existing historical data of futures price is too short in order to estimate MVHR and EWMA hedge ratio. However, the hedging effectiveness of naïve and beta-hedged strategy can be explored in the next few years since the historical price of futures contract is not required to perform these two basic hedging techniques. The futures price will be used in calculating ex-ante hedging effectiveness.

CONCLUSION AND FURTHER DEVELOPMENTS

Hedging simulated stock portfolios with KOSPI 200 index futures can effectively reduce the portfolio variance. For all examined portfolio sizes (which contain 5, 10, 15, 20 and 25 stocks) during 2003-2006, hedging can reduce portfolio variance by approximately 3% in absolute basis. Since the variance of unhedged portfolio is decreasing in portfolio size, hedging effectiveness measured by percentage reduction in portfolio variance has a positive relationship with portfolio size. For the hedge ratio estimation technique, MVHR is the best hedging technique in terms of highest hedging effectiveness. From 2003 to 2006, hedging effectiveness of 5-stock MVHR portfolio is around 39% and this number rises to 62% for the 25-stock MVHR portfolio. However, hedging effectiveness of the year 2005 is considerably low compared to other years since it is the bull period where correlations among individual stocks and index are relatively low. Besides the variance measurement, this paper also quantifies risk that focus on downside movement of returns which are worst weekly returns. This concept is similar to VaR (Value at Risk) based on historical simulation method. The results still show that MVHR is the best hedging technique from 2003 to 2006 since it yields the smallest worst weekly loss.

For the further developments, there are three major points worth to be considered. The first one is to expand the stock sample to include small capitalization stocks which are not the component of the KOSPI 200 index. Then, we can analyze the hedging effectiveness between large-capitalization stock portfolio and small-capitalization stock portfolio. Initially, the first one is expected to have higher hedging effectiveness but the magnitude is still unidentified. The second point is to apply this dynamic hedging to quantify hedged returns and risks of some selected fundamental or technical stock selection strategies. This point is very interesting since index futures hedging is popular among equity fund managers who are confident on their stock selection. The last point for the development is concentrated on more advanced techniques to estimate hedge ratio such as ECM and GARCH model. Although recent studies indicate that these more advanced methods can hardly outperform standard OLS, they used the underlying index as a cash portfolio instead of the typical stock portfolio.

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