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Abstract

In this paper two hedging models are studied in the context of the SPI futures. I analyze the hedge ratio and hedging effectiveness of the models relative to the naïve hedging model. Firstly, I find that Working's (1953) strategy enhances the performance of hedging over the naïve strategy. Secondly, based on risk reduction, the Variance Minimization model is found to be very useful. It performs better than the naïve model. The hedging effectiveness of a longer hedge duration is found to be more effective than a shorter one. Finally, the effects of time to expiration on hedge ratio and hedging effectiveness are not clear.

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1. INTRODUCTION

In February 1983, the Sydney Futures Exchange (SFE) introduced the All Ordinaries Share Price Index (SPI)[1] futures contract to the Australian financial market. It is considered as the first exchange outside the U.S. markets to trade stock index futures contracts. The SPI contract has proved to be successful. The average daily trading volume of the nearest to term contract was around 1,000 contracts in 1992 and has increased to around 9,000 contracts per day in 1997.[2] One major contribution of the SPI is that it provides an opportunity for investors to directly manage and hedge price risk that belongs to the undiversifiable risk (systematic risk) component of their equity portfolios without having to change the portfolios' composition [Figlewski (1984)].

Using stock index futures to hedge the price risk of an existing equity portfolio means undertaking a position in the futures contracts that offsets entirely or partially the price risk of the given equity position. Generally, the essence of hedging is the adoption of price change in a futures position(s) to offset price change in a given spot position(s).

One primary concern of hedgers is how to obtain a proper determination of the hedge ratio, the quantities of futures contracts to be held relative to quantities of a spot position, as well as the effectiveness measure of that ratio. The hedge ratio provides information on how many

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[1] The underlying asset of the SPI contract is the All Ordinary Index (AOI). Two points should be noted here. Firstly, the AOI is not a tradable asset in its own right. This leads to the necessity of the cash settlement provision. Secondly, the AOI is a capital gain index. Hence, it ignores any cash dividends received on the index portfolio. This means that, in practice, hedging the AOI index portfolio by SPI is a cross hedge, since by holding the index portfolio, investors are entitled to receive cash dividends.

[2] However, it should be noted that on 11 October 1993 the SPI was downsized from a value of A$100 to A$25 times the AOI. This means that the comparison of liquidity of the SPI contract before and after 11 October 1993 cannot be done directly using the volume of the contracts.

futures contracts should be held, whereas its effectiveness evaluates the hedging performance and the usefulness of the strategy. In addition, the hedgers may use the effectiveness measure to compare the benefits of hedging a given position from many alternative futures contracts.

The earliest form of hedge ratio is the 1:1 hedge or the naïve strategy. However, the strategy leaves the hedgers with basis risk exposure. In order to improve the performance of hedging activity, other optimal strategies have been suggested by, for example, Working (1953), Ederington (1979), and Howard and D'Antonio (1984).

The objectives of hedging are normally taken to be the first step in developing the hedging strategies. However, the objective of hedging has proved controversial. Working (1953) looks at hedging as a profit maximizing activity. Ederington (1979), on the other hand, suggests that the hedging position should be taken to minimize risk of a portfolio's return. Alternatively, Howard and D'Antonio (1984) takes the hedger's objective as the optimization the risk-return tradeoff. The differences in definitions of the objectives of hedging lead to different procedures of obtaining hedge ratios and the effectiveness measures.

These alternative hedging strategies have been constantly tested for stock index futures contracts in many markets around the globe. [U.S.: Figlewski(1984, 1987), Junkus and Lee(1985), Graham and Jenning(1987), Malliaris and Urrutia(1991), Lindahl(1991, 1992); Canada: Deaves(1994), Gagnon and Lypny (1997); Japan: Yau, Hill and Schneeweis(1990); U.K.: Holmes(1995, 1996); Hong Kong: Yau(1993): and Australia: Hodgson and Okunev(1992)] Most of the studies have been done in the U.S. context, whereas there are less comparable studies in the Australian context[3]. Therefore, the primary purpose of this paper is to investigate the economic function, particularly the hedging function, of the SPI contract in order to provide empirical evidence on its usefulness in the Australian financial market. Specifically, we consider the use of the SPI contract to reduce price risk of the All Ordinary Index (AOI) portfolio.

Previous studies have found that the use of the optimal models can enhance hedging performance of stock index portfolios over the use of naïve strategy. The examples are; Working's model: Junkus and Lee(1985); Variance Minimization model: Figlewski(1984, 1985), Holmes(1995, 1996), and Lindahl(1992). Accordingly, the second purpose is to test the applicability of these two optimal hedging strategies on the SPI contract. The test is aimed to find to what extent a hedger can be better off using these optimal strategies as opposed to the naïve alternative.

Due to differences in their assumptions regarding hedgers' utility functions and attitudes toward risk and return, the two optimal models define the objectives of hedging differently. Consequently, we will not compare the hedging performance between the two optimal models, rather we will compare the performance of each optimal model to the naïve strategy. The comparison will be done in each optimal model criterion.

[3] Hodgson and Okunev(1992) study hedging the basket of shares in the All Ordinary Index with the SPI contract. In that study, the authors use both the Variance Minimization and the extended mean Gini coefficient to compute alternative hedge ratios. They found that the two approaches lead to different hedge ratios.

Holmes (1995, 1996) has reported that although the optimal models improve the hedging performance over the naïve strategy, the improvement reduces when the tests assume that investors use hedge ratio from the last period to hedge in the next period, i.e. ex ante. Since, in practice, it is likely that hedgers apply the hedge ratio estimated using historical data to hedge in the coming period, the ex ante test would be more practical than the ex post test. To address the issue, this paper investigates the hedging effectiveness on both ex post and ex ante settings.

As investigated in Lindahl(1992), differences in hedge durations and time to expiration of the futures contracts have direct effects on the hedge ratios and hedging performance. Therefore, the last purpose of this paper is to investigate the effects of hedge duration and time to expiration on hedge ratios and hedging effectiveness of the SPI contract.

The plan of this paper is as follows. Section II reviews theories on futures contract hedge ratios. Section III states the assumptions used in this study. Section IV examines the data as well as methodology employed in the paper. Section V presents the results. Finally, section VI is the conclusion.

2. REVIEW OF HEDGING THEORIES

There are three main views of hedging strategy concerning the calculation of hedge ratios and their effectiveness.

2.1 Traditional Theory of Hedging (Naïve Strategy)

Traditionally, it is assumed that the objective of hedging is taken to be *risk minimization* [Sutcliffe(1997)]. The theory implicitly assumes that the hedgers are *extremely risk averse*, and want to eliminate all price risk incurred in their spot portfolio. To achieve the objective, it suggests the hedgers to undertake an opposite, but equal in magnitude, position in the futures market with regard to the given spot position. The hedge ratio at time t (b_t) [4] is defined as;

$$b_t \quad = \quad -(X_{f,t} / X_{s,t}) \qquad (1)$$

where X_s and X_f are quantities (in terms of units of the index) of the spot or cash asset and the futures contract held by the investor, respectively.

In this view, the strategy is to use b_t equal to 1, or a 1:1 hedge, and hence it is called the "naïve strategy". To use stock index futures contracts for hedging an equity portfolio, this approach requires adjustment of the hedge ratio to take account of the portfolio beta, i.e. b_t =

[4] Using the hedge ratio, b_t, the number of futures contracts for an investor holding *$M* worth of the AOI portfolio can be determined as;

$$n \quad = \quad -b_t M / \$25{*}S \quad \text{contracts.}$$

Here S refers to the level of the AOI index, and one SPI contract worth $25*S. Note that the negative sign reflect the opposite position in the spot and the futures markets, i.e. long spot ($X_s > 0$) versus short futures ($X_f < 0$).

b_p [Lindahl(1992)]. Since this paper uses the AOI as the given spot portfolio, the hedge ratio is still unity.

The unity hedge ratio eliminates price risk of a spot position only when the hedge involves no basis risk. Therefore, the theory implicitly assumes that the basis risk is always zero, where the basis is defined as;

$$BASIS_t = S_t - F_t \qquad (2)$$

where S is the spot price,

F is the futures price.

This appears to be its drawback. Realistically, the naïve hedge is said to be without basis risk if the underlying asset on the futures and the asset to be hedged are the same, and if the hedge is lifted on the futures maturity. Another situation is when proportionate price changes in the two markets, spot and futures, are identical [Holmes(1995)]. With the SPI contract, there are only four maturity dates of the contract in a year. Therefore, in practice, the hedgers always face maturity mismatch, the hedge lifting date does not coincide with the contract maturity. In addition, over the course of the futures contract life, the price changes in the two markets are not correlated perfectly. This leaves the hedgers with basis risk. Consequently, the naïve hedge does not eliminate all the price risk in the spot position, rather it transforms price risk into basis risk.

2.2 Working's Theory of Hedging (Profit Maximization)

Working (1953) views the hedger as a *risk selector*, rather than a risk averter as implied in traditional view [Castelino (1992)]. The primary objective of hedging is to *maximize profit* from a combination of futures and spot, a hedged position. The profits in dollar ($P_{h,t+k}$) and percentage ($R_{h,t+k}$) terms are defined as;

$$
\begin{aligned}
P_{h,t+k} &= X_{s,t}\,(S_{t+k} - S_t) + X_{f,t}\,(F_{t+k} - F_t) \\
&= X_{s,t}\,[(S_{t+k} - S_t) - b_t\,(F_{t+k} - F_t)\,] \qquad (3)
\end{aligned}
$$

$$
R_{h,t+k} = P_{h,t+k} / S_t \qquad (4)
$$

where h is the subscript denoting the hedged portfolio,

$t+k$ is the subscript for time t+k which is assumed to be the end of a hedging period, the lifting date.

In this view, hedges are placed if the hedgers believe that futures prices reflect an attractive profit opportunity when compared to the spot price [Castelino(1992)]. Additionally, Working found that a large negative basis was likely to be followed by a large positive change in the basis, and vise versa [Junkus and Lee(1985)]. As a result, one may develop a decision rule for hedging in this framework as; in short (long) hedge, the hedge should be undertaken (i.e. b_t = 1), if the basis at the beginning of the hedge period is sufficiently narrow or negative (wide or positive) to allow the hedgers to believe that the basis change will be in positive (negative) direction, a change favorable to the hedgers, otherwise the position should be left unhedged (i.e. $b_t = 0$) [Junkus and Lee(1985): p.203-204]. In essence, Working's theory may be viewed as *speculating on the basis*.

The hedge ratio, b_t, according to this theory is 1 if the decision to hedge is made, and 0 otherwise. In applying this strategy, the decision variable is the size of basis. The hedgers have to determine at what level the basis is said to be low enough. Obviously, the success of the strategy relies heavily on the negative relationship between the level of the current basis and its change in the next period.

Since the objective of hedging according to Working is to maximize the profit of the overall position, the effectiveness of this strategy can be measured by the increase in average profits over the naïve strategy [Junkus and Lee(1985)].

$$HE_W = R_{h,W} - R_{h,N} \qquad (5)$$

where HE is the measure of hedging effectiveness,

W and N are the subscripts denoting for Working's and Naïve strategies, respectively.

The interpretation of HE_W is straightforward. If $HE_W > 0$, then Working's strategy improves the performance of the hedging over the naïve strategy, and it should be implemented as the optimal hedging strategy. On the other hand, if $HE_W < 0$, the naïve strategy is more preferable. The higher the HE_W is translated into higher the hedging effectiveness, or performance.

The applicability of Working's strategy in stock index futures has been studied in Junkus and Lee(1985). In that paper, the authors study 3 US stock index futures contracts; NYSE, S&P500, and VLCI, with 3 different contract maturities; short (the closest to maturity or in a delivery month the next closest contract), long (the farthest from maturity available in that hedge month), and intermediate maturities. Initially, the authors document the strong negative relationship between basis size ($BASIS_t$) and change in the basis ($BASIS_{t+k}$ - $BASIS_t$). This negative relationship is essential for success of the decision rule in Working's theory. Further, they found that in all cases the use of Working's strategy leads to a greater return relative to the naïve strategy, i.e. $HE_W > 0$. However, the results depend heavily on both the size of the basis used in the decision rule, and time to expiration of the futures contract. As the size of basis becomes larger, the HE_W*'s* become smaller. Finally, the highest HE_W is obtained from the contracts with the shortest time to maturity.

2.3 Portfolio Approach to Hedging (Utility Maximization)

In this view, return and risk are defined in terms of mean and variance of returns, the concepts of the modern portfolio theory. The use of portfolio theory in hedging decisions may be traced to Stein(1961), later in Ederington(1979), Howard and D'Antonio(1984), and many others.

The rationale underlying the theory is that hedgers are risk-averse agents who try to maximize their utility through the increase of wealth. Given the hedger's degree of risk aversion, the hedger chooses to hedge partially or fully in an attempt to trade-off risk against returns [Castelino(1992), see also Sutcliffe(1997: p.260)]. However, the utility functions and the degrees of risk aversion assumed (either explicitly or implicitly) are different from one model to the other.

The portfolio approach to hedging allows a wide range of hedge ratios to be efficient (i.e. along the efficient frontier), depending on the agent's degree of risk aversion. According to Duffie(1989: p.211-215), the optimal futures can be divided into the speculative and pure hedging components. However, the speculative position depends on an agent's risk aversion and may be difficult to estimate. On the other hand, the pure hedge position (i.e. the risk minimizing position) does not depend on the agent's risk aversion. The calculation of a pure hedge can be useful to many different agents where they can add on their own speculative demands. Thus, in this paper, we choose to investigate one model of the portfolio approach, the Variance Minimization model of Ederington(1979). As will be explored later, this model calculates the risk minimizing hedge ratio.

Variance Minimization (V-M) Strategy

According to Ederington(1979), the objective of a hedge is to minimize the risk of the overall position, where risk is measured by the variance of the portfolio return. The hedger is viewed as extremely risk averse as in the traditional theory. The strategy can be translated into the optimization problem as follows;

Define the rate of return on a hedged portfolio, and its variance as:

$$R_{h,t+k} = (X_{s,t} S_t R_{s,t+k} + X_{f,t} F_t R_{f,t+k}) / X_{s,t} S_t \qquad (6)$$

$$s^2_h = (1 / X_s S_t)^2 [X_s^2 S_t^2 s^2_{Rs} + X_f^2 F_t^2 s^2_{Rf} + 2 X_s X_f S_t F_t s_{Rs,Rf}]$$

$$= (1 / X_s S_t)^2 [X_s^2 S_t^2 s^2_{Rs} + b_t^2 X_s^2 F_t^2 s^2_{Rf} - 2 b_t X_s^2 S_t F_t r s_{Rs} s_{Rf}] \qquad (7)$$

where $R_{s,t+k} = (S_{t+k} - S_t) / S_t$, and $R_{f,t+k} = (F_{t+k} - F_t) / F_t$

s^2_h , s^2_{Rs} , s^2_{Rf} are the variance of the return on the hedged portfolio, the spot, and the futures price , respectively

$s_{Rs, Rf}$ is the covariance between the spot return and the futures return,

r is the correlation between R_s and R_f

The optimization problem is to minimize s^2_h with respect to b_t. Using the First Order Condition and the relationship from equation (1), we can solve for the value of b_t. The solution for b_t is the optimal hedge ratio of the V-M model, b_t*. This solution can be given as;

$$b_t^* = (S_t / F_t) [s_{Rs,Rf} / s^2_{Rf}] \qquad (8)$$[5,6]

[5] The term $[s_{Rs,Rf} / s^2_{Rf}]$ may, alternatively, obtained from the value b_1 of the regression $R_{s,t} = b_0 + b_1 R_{f,t} + e_t$. The optimal hedge ratio is then defined as; $b_t^* = (S_t / F_t) b_1$. Note that if the rate of return on futures prices is defined as $R_{f,t} = (F_{t+k} – F_t) / S_t$, then $b_t^* = b_1$ of the above equation. The use of this definition of futures return can be found in Figlewski(1984, 1985).

[6] By applying OLS, there are many considerations regarding the residuals, such as autocorrelation and heteroscedasticity. These problems can be partly solved by using more complicated econometric methods, for example, Holmes(1996) employs GARCH model to incorporate nonconstant variance and covariance. Ghosh(1993a, b) suggest the use of ECM when the spot and futures returns are cointegrated.

The ADF tests reveal that spot and futures return series (weekly, two weekly, and four weekly) used in this paper are stationary. Furthermore, by using complicated econometric methods one risks losing the sight of the

Since the objective of hedging in this view is to minimize variance of return, the corresponding measure of hedging effectiveness can be found by measuring the extent to which the portfolio return variance is reduced relative to the unhedged position. This can be expressed as;

$$HE_E \quad = \quad [s^2_{Rs} - s^2_h] \; / \; s^2_{Rs} \qquad (9)^{7}$$

The higher the HE_E the better the contract and/or the strategy is in reducing the portfolio variance. The degrees of variance (risk) reduction are translated into efficacy of the contract and/or the strategy. For a given spot portfolio and a futures contract, the HE_E is high if s^2_h is low. From equation (7), it is shown that s^2_h is negatively related to r. Thus, the higher the correlation between the futures price return and the spot portfolio return, the higher the effectiveness of the contract.

Many aspects of the V-M model have been tested empirically in the context of stock index futures. Firstly, the applicability of the model has been documented. Various studies found that, in ex post setting[8], the V-M model enhances the risk reduction performance of hedging

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objective, which is to estimate $s_{Rs,Rf} / s^2_{Rf}$, not the slope coefficient of the regression equation [Sutcliffe(1997) p.284)]. Therefore, I will confine the analysis to simple OLS.

[7] If the rate of return on futures price is defined as $R_{f,t} = (F_{t+k} - F_t) / S_t$, then the HE_E is the R^2 of the regression equation $R_{s\,t} = b_0 + b_1 R_{f,t} + e_t$.

[8] The assumption underlying the ex post test is that the hedgers have a perfect knowledge of the price movement in both spot and futures markets. That test is done by using data in the same period of the hedging to calculate the hedge ratio. On the other hand, the ex ante test assumes that the hedgers use historical data to estimate the hedge ratio for hedging in the coming period.

over the naïve strategy [Figlewski(1984, 1985), Graham and Jennings(1987)]. However, Holmes(1995, 1996) found that the enhancement is at lower extent when the tests are done in the ex ante setting. In all cases, the V-M hedge ratio is less than the hedge ratio suggested by the naïve strategy (i.e., $b_t* < 1$).

Secondly, the duration effect and the expiration effect have been studied in Lindahl(1992) and Holmes(1996). The general result is that as the hedge duration increases, the V-M hedge ratio increases toward unity, but they all are significantly less than one. For example, using the futures contract on S&P 500, Lindahl(1992) found the b_t*'s are 0.927, 0.965, and 0.970 for 1, 2, and 4 week hedge duration, respectively. The effectiveness of the model also increases with the hedge duration. The explanation is that as the duration increases the variance of returns increases and thus the proportion of total risk accounted for by basis risk will decrease. Therefore, the hedging effectiveness should increase with the increase in duration [Holmes(1996)].

The fact that futures prices converge toward cash prices as expiration approaches gives theoretical merit to analyzing the expiration effect. If the futures prices are also less volatile as expiration approaches, the V-M model hedge ratio can expected to converge toward the naïve hedge ratio [Lindahl(1992)]. The author found that the hedge ratios were generally less than unity, and that as time to expiration on the lifting date get smaller the hedge ratio increased toward unity. However, Holmes(1996) does not find the same pattern.

Thirdly, in order to calculate the V-M hedge ratio, one has to estimate the $(s_{Rs,Rf} / s^2_{Rf})$ by using historical data. The decision on the length of estimation period has to be made. If the length is too long, the hedgers risk the use of irrelevant data. On the other hand, if it is too short the data might not be a good representative of the true relationship between R_s and R_f. This decision obviously affects the effectiveness of the hedging strategy. Holmes(1995) found that once the estimating period is shortened the effectiveness of the ex post hedge increases, while the effectiveness of ex ante hedge decreases.

3. ASSUMPTIONS

The followings are assumptions used throughout the study.

1. We assume the hedger is holding the AOI portfolio (long spot). In order to hedge, he is considering to sell the SPI futures contract (short hedge). Note that we use the return on the AOI to represent the return on the index portfolio. Hence, the hedging analyzed here is only for capital gain risk.[9,10]
2. In testing various models, the size of spot position to be hedged is assumed to be known with certainty, i.e. fixed. This leaves our optimization problem with only one decision variable, the size of futures contract to be held. Note that this may not always be the case. [see Lindahl(1992) p.35, and Sutcliffe(1997) p.258, for examples where this assumption is appropriate]
3. To keep the analysis simple, we ignore any effect due to taxes, transaction costs, indivisibility, initial and variation margin, and any other market imperfections.

[9] See footnote 1.

[10] In Figlewski(1984), the test of hedging an index portfolio using stock index futures covers for both capital gain and dividend risk. However, he found that dividend risk constitutes to only a small proportion of total risk of the index portfolio. To modify the analysis of this paper to cover dividend risk, one may use the All Ordinary Accumulated Index, rather than the All Ordinary Index.

4. The hedgers are assumed to hedge and, then, hold the hedged position until the end of hedging period (the lifting date). This is a single period hedge.
5. The hedgers are assumed to use the nearest to maturity contract (0-3 months). However, to reduce the complication of rolling over during the hedge period, we further assume that the hedgers only use the contract that will not be expired before the lifting date. This leads to occasional use of the next contract.

4. DATA AND METHODOLOGY

In this paper, the hedging effectiveness of the SPI contract is examined under the framework of two optimal models, Working's model, and the V-M model. The effectiveness of hedge ratios from each optimal model are compared with that of the naïve strategy in each model comparison. The hedging effectiveness is investigated for three different hedge durations, 1, 2, and 4 weeks. The effect of hedge duration can, thus, be examined. In addition, the effect of time to expiration is also investigated.

The data used in the study cover the period of five and a half years, from January 1992 to July 1998. The daily closing price of the SPI contract and the AOI are obtained from SFE and Datastream, respectively. Since there are least missing prices for Wednesday, we use Wednesday prices to calculate weekly, 2-weekly, and 4-weekly returns in both markets. This leaves us with 343, 171, and 85 observations of weekly, 2-weekly, and 4-weekly returns, respectively. For SPI, the nearest to maturity contracts are examined, except that whenever the nearest contract will be expired before the lifting date, we use the next contracts.

Working's Theory

In line with the previous study by Junkus and Lee(1987), we begin the analysis of Working's strategy by running the regression equation:

$$BASIS_t = \quad b_0 + b_1 (BASIS_{t+k} - BASIS_t) + e_t \qquad (10)$$

where k is 1, 2, and 4 weeks for 1, 2, 4 week duration of the hedges, respectively.

The significant negative relationship between $BASIS_t$ and $(BASIS_{t+k} - BASIS_t)$ is important for the success of the strategy. The results from equation (10) would give us insight in that regard.

Following Junkus and Lee(1985), we will test the applicability of Working's theory using the following decision rule; "For short hedge, the hedges are placed (b_t = 1) if the basis at the beginning of the hedge period is less than or equal to Y, otherwise leave the position unhedged (b_t = 0)". *Y's*, the basis sizes used in the decision rule, are varied from -40 to 30 basis points with the incremental of 10 basis points.

We use equation (4) to calculate portfolio returns from the naïve and Working's strategy with different basis sizes (*Y's*). The returns are annualized using simple interest rate, i.e. by multiplying 52, 26, and 13 to 1,2, and 4 week returns, respectively. These returns from the two strategy are then compared by means of equation (5). The resulted values, HE_W, are then averaged for a whole as well as for each year of the sample periods.

The hedge duration effect is examined by comparing the HE_W from three different hedge durations. Then, the time to expiration effect is examined by dividing the hedge sample into groups that have *i*'s weeks to expiration on the lifting date, where *i's* = 0-4, 5-8, and 9-13 weeks[11]. The resulted HE_W 's from each group are then compared.

Variance Minimization Model

The optimal hedge ratios are derived from equation (8), for 1,2, and 4 week hedge period, respectively. To investigate the applicability of the model, we calculate its effectiveness using equation (9), then compare with the naïve strategy.

We first investigate hedging performance by using the full sample to calculate the $[s_{Rs,Rf}/s^2_{Rf}]$, which is, in turn, used to calculate hedge ratios for the whole sample period (call this ratio *b**). The (S_t / F_t) is derived at the beginning of the hedge. Next, we calculate $[s_{Rs,Rf}/s^2_{Rf}]$ using only 1 year of data, and use it to calculate the hedge ratios in that particular year (call this ratio *b*(1)*). We do this for each year in the sample. In these initial analyses the estimation period covers the hedging period. The underlying assumption is that the hedgers have knowledge of what will happen to the prices in the two markets, i.e. ex post test.

To make the study more practical, we assume that the hedgers use historical information to calculate $[s_{Rs,Rf}/s^2_{Rf}]$, and use it to obtain hedge ratios in the following period (call this ratio *b*(-1)*). This is an ex ante test. In this initial analysis, we assume the hedgers use $[s_{Rs,Rf}/s^2_{Rf}]$

[11] Here, we did not analyze the expiration effect on the week by week basis for the sake of numbers of observations. The numbers of observation reduce dramatically, as the size of the *i*'s become smaller.

estimated from a previous year to hedge in the next year. Here the $[s_{Rs,Rf} / s^2_{Rf}]$ is kept constant for the next whole year, and recalculated at the beginning of the following year.

Since it would be more realistic to assume the hedgers to use more recent information to calculate $[s_{Rs,Rf} / s^2_{Rf}]$, next we employ a moving window procedure. It is started by estimating $[s_{Rs,Rf} / s^2_{Rf}]$ using the first J observations, i.e., 1^{st} to j^{th} observations. This $[s_{Rs,Rf} / s^2_{Rf}]$ is used for hedging from period j to $j+1$. At the beginning of period $j+1$, we re-estimate $[s_{Rs,Rf} / s^2_{Rf}]$ by subtracting the first observation and adding the next observation, i.e. using the 2^{nd} to $j+1^{th}$ observations. In this way we keep the window size of J observations constant. This procedure is continued in all subsequent periods.

Using the moving window procedure above, the effect of estimation period length is investigated by allowing J to be varied from 4 to 52 weeks. In order to keep the numbers of observations and the time period comparable, we start this ex ante test on the first week of January 1993. This means that for 52 week window we use all observations in 1992, but for 4 week window we use only the last four weeks of observations (i.e., December) in 1992.

Following the previous literature, the issue of time to expiration effect on the hedge ratios is investigated by means of multiple regression with dummy variables.[12]

[12] The use of dummy variables and multiple regression is preferred to the use of simple regression. The reason is that the multiple regression saves the degree of freedom relative to the simple regression. This is because to use simple regression, to obtain all β_i's, one has to estimate equation (9) for each time to expiration says 0 , 1, 2, …, 12 weeks for one week hedge period. The constant terms are calculate 13 times in this simple regression, whereas in the multiple regression we estimate only 1 constant term to get all β_i's.

$$R_{s,t} \quad = \quad b_0 + b_1 R_{f,t} D_0 + b_2 R_{f,t} D_1 + \ldots\ldots + b_{n+1} R_{f,t} D_n + e_t \qquad (13)$$

where $b_1, b_2, \ldots b_{n+1}$ are $cov(R_s,R_f) / var(R_f)$ for hedges with 0, 1, …, n weeks to expiration,

D_i is 1 for hedge lifted with i week to expiration, 0 otherwise,

For hedge period of 1 week; i = 0, 2, 3, …, 13

2 week; i = 0, 2, 4, …, 12

4 week; i = 0, 4, 8, , 12

The hedge ratios for each time to expiration are the average of the multiple of the (S_t / F_t)'s of each expiration and the b_i's.

5. RESULTS

5.1 Results from Working's Strategy

Table 1 shows the results from regression equation (10). All, but three, b_1's are significantly negative at the 1% level of confidence. However, at the 5% level of confidence, all of them are said to be significantly negative. As far as R^2's are concern, although they are not generally very high (they vary from 0.20 to 0.60), we would expect the relationship to be strong enough to implement Working's strategy for the SPI contract.

To begin, we test the applicability of Working's strategy in the context of SPI contract and the AOI portfolio. Table 2.1, 2.2, and 2.3 show HE_W's, the differences of the average simple annualized rate of return between the Working's strategy and the naïve strategy, of 1, 2, and 4 weeks hedge duration, respectively. The HE_W for each sample period is calculated from the average of *HE_W's* in that period. The first row contains the various basis sizes used in the decision rule, *Y's*. The italic numbers underneath the *HE_W's* show the number of times the hedges are committed if Working's strategy is used. The last column is the numbers of observations that are, also, the numbers of times the hedges are committed if one uses the naïve strategy.

Since as *Y* become larger Working's strategy leads to more and more hedged positions, to that end the strategy works more and more like the naïve one. This is reflected in the *HE_W's* decline toward 0 as *Y* increases. Recall that the higher the HE_W the more effective the strategy over the naïve model, and vise versa.

The results from the overall sample indicate the usefulness of Working's model as a way to increase returns over the naïve model. A closer look demonstrates that as *Y* decreases from 30 basis points, the HE_W increases. However, when *Y* becomes more and more negative, the HE_W seems to hit the highest level, and then begins to decline. The finding here is that an optimal level of *Y* should exist, the deviation from this level to either sides leaves the results sub-optimal. These optimal levels are different for different hedge durations. They are -10 basis points for 1, and 2 weeks hedge duration and -40 basis points for 4 week hedge duration.

By looking at the results of each year, one would find that the optimal level of *Y* changes over time. For example, for 1 week hedge, in 1992, the optimal level was 10 basis points, but it was -10 basis points in 1993. Using the inappropriate level of *Y* may result in hedging performance worse than the naïve strategy. Thus, in practice the decision on *Y* is very important for the strategy. However, in the long run (i.e. look at the whole sample) Working's strategy does perform at least as well as the naïve strategy, regardless of the value for Y chosen.

The hedging performance is more sensitive to the level of Y in the short run than in the long run. Two implications can be drawn. Firstly, if one can predict the optimal level of Y in each year correctly, the overall HE_W would be higher than that are reported here. This is because, in the results from the whole sample, we assume the hedges use constant level of Y for every year. Secondly, Working's strategy seem to be more viable in the long run than in the short run if one use a more passive strategy of constant Y.

To state the issue of hedge duration effect, we compare the whole sample HE_W's from table 2.1-2.3. The results indicate that for $Y \geq -20$ the longer hedge duration, the higher the hedging effectiveness. For $Y \leq -30$, the results are opposite.

Table 3 shows the average HE_W's from groups of different contracts that are divided according to their time to maturity on the lifting date. Junkus and Lee(1987) report that as Y become less than 0, the closer to maturity contracts provide higher hedging effectiveness, compared to the longer to maturity contracts. The results here contradict that finding. The hedging performance of Working's theory does not seem to have any relationship with time to expiration of the contract.

To summarize we found that in the long run a hedger can adopt Working's strategy as a way to increase hedged portfolio return relative to the naïve strategy. The results might not be true for the short run. The results indicate both the applicability of the strategy and the usefulness of the SPI contract.

5.2 Results from Variance Minimization Strategy

Tables 4.1, 4.2, and 4.3 show the hedging effectiveness of the from naïve strategy (1:1 Hedge), and Variance Minimization (hereafter V-M) model (HE_E) from 1, 2, and 4 week hedge durations, respectively. The HE_W*'s* of the Variance Minimization model are calculated by three different approaches, as described in the Methodology Section. The italic numbers underneath each HE_W are the average hedge ratio. We find that the two strategies lead to substantial risk reduction, compared to the unhedged AOI portfolio. The risk reduction ranges from 88% to 99% for the whole sample. In general, the results indicate that the V-M model out performs the naïve strategy. This is true for both the ex post (b^* and $b^*(1)$) and ex ante ($b^*(-1)$) approaches. In addition, in all cases the hedge ratios of the V-M model are statistically less than unity at 1% confidence level. This is consistent with previous research.

A closer look at the performance of V-M model reveals that the ex post hedge is more effective than the ex ante hedge. This should be expected because the ex post test assumes the hedgers have a knowledge of prices movement when the hedge is lifted. On the other hand, the ex ante hedge assumes the hedgers use previous information to estimate $[s_{Rs,Rf} / s^2_{Rf}]$ and in turn calculate the hedge ratio. If the hedge ratios are not constant over time the ex ante hedge would be less effective.

However, it should be noted that the hedging performance of the ex ante hedge ($b^*(-1)$) is not substantially inferior to the ex post hedge ($b^*(1)$). This means, based on risk reduction alone,

one may use the hedge ratio based on past information to hedge successfully. Therefore, the V-M model provides a viable strategy for hedgers who consider using the SPI contract to reduce price risk in the AOI portfolio.

The hedge duration effect is investigated through comparing the HE_W's from table 4.1-4.3. Firstly, the hedge ratios are significantly less than unity for all hedge durations. However, they increase towards unity as the hedge duration increases. The overall b^* from 4 week hedge duration is significantly greater than b^* from 2, and 1 week hedge duration. The b^* from 2 week is also significantly greater than b^* from 1 week hedge duration. The pattern is the same for $b^*(1)$ and $b^*(-1)$, except for $b^*(-1)$'s of 4 and 2 week hedge duration. The significance tests are done at 5% level. Secondly, the hedging performances increase as the hedge duration increases.

Next, we adopt the moving window procedures to estimate $[s_{Rs,Rf} / s^2_{Rf}]$. The results are shown in Table 5. For the whole period 1993-1998/7, the results of 52 week window size compared with the procedures used in Table 4.1-4.3 reveal that using moving window technique gives higher HE_E's in both ex post and ex ante setting for all hedge durations.

Hedging performance is affected by the choice of estimation period. For 1 and 2 week hedge durations, the ex post hedging effectiveness appears to increase as the window size decreases. The outcomes are opposite for the ex ante hedge of 1 and 2 week hedge durations. These results are what we would expect. In the ex post hedge, we include the price movements on the lifting date in the calculation for $[s_{Rs,Rf} / s^2_{Rf}]$. The shorter the estimation period, the relatively greater the weight that is given to this price. Therefore, we would expect the ex post hedge to perform well if the estimation period is short. On the other hand, in ex ante hedge, the hedgers use past data. The shorter estimation the relatively greater weight that is given to each observation. $[s_{Rs,Rf} / s^2_{Rf}]$ may be effected more by outliers, compared to the use of a longer estimation period.

Table 6 shows results of expiration effect on the hedge ratio and hedging effectiveness. We do not find that there is a clear pattern of the hedge ratios rising toward unity as the lifting approaches time to expiration. This result is different from Lindahl(1992), but similar to Holmes(1996). As far as the hedging performance is concerned, there also no sign of increasing hedging effectiveness as the time to expiration approaches. This result is consistent with Lindahl(1992) and Holmes(1996).

6. CONCLUSION

In this paper the hedging performance of the SPI futures contract is studied with two optimal hedging models, Working's model and the Variance Minimization model. We found in support of the usefulness of the SPI contract as a hedging vehicle for the AOI portfolio. In addition, on the stand point of profit maximization, Working's strategy is found to be a viable strategy in the long run. However, in short run the performance of the strategy is more sensitive to the basis level used in the decision rule.

The Variance Minimization model is found to be very applicable from the risk reduction stand point. We found that even the simple use of the hedge ratio calculated from past data can reduce risk (variance of the portfolio return) by up to 90%.

REFERENCES

Castelino, M.G. (1992), “Hedge Effectiveness: Basis Risk and Minimum-variance Hedging,” *Journal of Futures Markets*, vol.12(2), pp.187-201.

Deaves, R. (1994), “Naïve versus Conditional Hedging Strategies: The Case of Canadian Stock Index Futures,” *Canadian Journal of Administrative Sciences*, vol.11(3), pp.264-270.

Duffie, D. (1989), *Futures Markets*, Prentice-Hall, Englewood Cliffs, New Jersey. [Chapter 7]

Ederington, L.H. (1979), “The Hedging Performance of the New Futures Markets,” *Journal of Finance*, vol.23(1), pp.157-170.

Figlewski, S. (1984), “Hedging Performance and Basis Risk in Stock Index Futures,” *Journal of Finance*, vol.39(3), pp.657-669.

Figlewski, S. (1985), “Hedging with Stock Index Futures: Theory and Application in a New Market,” *Journal of Futures Markets*, vol.5(2), pp.183-199.

Franckles, C.T. (1980), "The Hedging Performance of the New Futures Markets: Comment," *Journal of Finance*, vol.35(5), pp.1273-1279.

Gagnon, L. and Lypny, G. (1997), “The Benefits of Dynamically Hedging the Toronto 35 Stock Index,” *Canadian Journal of Administrative Sciences*, vol.14(1), pp.69-78.

Ghosh, A. (1993a), “Cointegration and Error Correction Models: Intertemporal Causality between Index and Futures Prices,” *Journal of Futures Markets*, vol. 13(2), pp. 193-198.

Ghosh, A. (1993b), “Hedging with Stock Index Futures: Estimation and Forecasting with Error Correction Model,” *Journal of Futures Markets*, vol. 13(7), pp. 743-752.

Graham, D. and Jenning, R. (1987), "Systematic Risk, Dividend Yield and the Hedging Performance of Stock Index Futures," *Journal of Futures Markets*, vol.7(1), pp.1-13.

Hodgson, A. and Okunev, J. (1992), "An Alternative Approach for Determining Hedge Ratios for Futures Contracts," *Journal of Business Finance and Accounting*, vol.19(2), pp.211-224.

Howard, C.T. and D'Antonio, L.J. (1984), "A Risk-Return Measure of Hedging Effectiveness," *Journal of Financial and Quantitative Analysis*, vol.19(1), pp.101-112.

Holmes, P. (1995), "Ex Ante Hedging Ratio and Hedging Effectiveness of the FTSE-100 Stock Index Futures Contract," *Applied Economic Letters*, vol.2(3), pp.56-59.

Holmes, P. (1996), "Stock Index Futures Hedging: Hedge Ratio Estimation, Duration Effects, Expiration Effects and Hedge Ratio Stability," *Journal of Business Finance and Accounting*, vol.23(1), pp.63-77.

Hull, J. (1997), *Options, Futures, and Other Derivatives*, 3rd edn, Prentice Hall, USA. [Chapter 2]

Junkus, J.C. and Lee, C.F. (1985), "Use of Three Stock Index Futures in Hedging Decisions," *Journal of Futures Markets*, vol.5(2), pp.201-222.

Lindahl, M. (1989), "Measuring Hedging Effectiveness with R^2: A Note," *Journal of Futures Markets*, vol.9(5), pp.469-475.

Lindahl, M. (1992), "Minimum Variance Hedge Ratios for Stock Index Futures: Durations and Expectation Effects," *Journal of Futures Markets*, vol.12(1), pp.33-53.

Malliaris, A.G. and Urrutia, J. (1991), "Tests of Random Walk of Hedge Ratios and Measures of Hedging Effectiveness for Stock Indexes and Foreign Currencies," *Journal of Futures Markets*, vol.11(1), pp. 55-68.

Rendleman, R.J. (1993), "A Reconciliation of Potentially Conflicting Approaches to Hedging with Futures," *Advances in Futures and Options Research*, vol.6, edited by D.M. Chance and R.R. Trippi, JAI Press Inc., Greenwich, Connecticut, pp.81-92.

Stein, J.L. (1961), "The Simaltaneous Determination of Spot and Futures Prices," *American Economic Review*, vol.51(5), pp.1012-1025.

Sutcliffe, C.M.S. (1997), *Stock Index Futures: Theories and International Evidence*, 2nd edn, International Thomson Business Press, Cambridge. [Chapter 11]

Working, H. (1953), "Futures Trading and Hedging," *American Economic Review*, vol.43(3), pp.314-343.

Yau, J. (1993), "The Performance of the Hong Kong Hang Seng Index Futures Contract in Risk-Return Mangement," *Pacific-Basin Finance Journal*, vol.1, pp.381-406.

Yau, J., Hill, J. and Schneeweis, T. (1990), "An Analysis of the Effectiveness of the Nikkei 225 Futures Contracts in Risk-Return Management," *Global Finance Journal*, vol.1(4), pp.255-276.

Table 1: The Regression Results of Equation *12*

The table reports the regression results of the equation *12*;

$$BASIS_t = \quad b_0 + b_1 (BASIS_{t+k} - BASIS_t) + e_t$$

	1 week Duration		2 week Duration		4 week Duration	
	Beta1	**R^2**	**Beta1**	**R^2**	**Beta1**	**R^2**
All Sample	-0.5002[b]	0.2291	-0.4985[b]	0.3209	-0.4975[b]	0.3605
1992	-0.5115[b]	0.2016	-0.5129[b]	0.3207	-0.5148[a]	0.3734
1993	-0.4679[b]	0.3802	-0.4519[b]	0.4643	-0.4392[b]	0.5649
1994	-0.5067[b]	0.2280	-0.5075[b]	0.3799	-0.5078[a]	0.3784
1995	-0.4925[b]	0.4254	-0.4890[b]	0.4125	-0.4831[a]	0.3895
1996	-0.5197[b]	0.2589	-0.5258[b]	0.4373	-0.5341[b]	0.5895
1997-1998(7)	-0.5100[b]	0.2903	-0.4922[b]	0.4065	-0.5013[b]	0.3971

[a] Less than zero at 5% confidence level

[b] Less than zero at 1% confidence level

Table 2: The Hedging Effectiveness of Working's Strategy (HE_W)

Tables 2.1, 2.2, and 2.3 report HE_W or "the average improvement in profit (in annualized rate of return) of Working's strategy over the naïve strategy" for 1,2, and 4 week hedge duration, respectively. For different basis sizes used in the decision rule (Y's), the HE_W is calculated using equation *5*;

$$HE_W \quad = \quad R_{h,W} \;-\; R_{h,N}$$

The italic numbers underneath each HE_W show the number of times the hedges are committed when Working's strategy is used

Table 2.1: HE_W for 1 Week Hedge Duration

	Basis Size Used in the Decision Rule (*Y*)								**No. Of**
	< -40	**< -30**	**< -20**	**< -10**	**< 0**	**< 10**	**< 20**	**< 30**	**Obs.**
Whole Sample	0.0550	0.0565	0.0771	0.1045	0.0694	0.0334	0.0155	0.0012	
	7	*27*	*82*	*163*	*257*	*314*	*333*	*341*	**343**
1992	-0.0796	-0.0784	-0.0791	-0.0190	0.0174	0.0274	0.0000	0.0000	
	0	*1*	*7*	*16*	*35*	*48*	*52*	*52*	**52**
1993	0.2907	0.2907	0.2933	0.3934	0.1375	0.0306	0.0000	0.0000	
	0	*0*	*5*	*23*	*37*	*51*	*52*	*52*	**52**
1994	-0.0675	-0.0695	0.0173	0.0357	0.0758	0.0907	0.0780	0.0076	
	2	*5*	*7*	*19*	*27*	*36*	*44*	*51*	**52**
1995	0.0979	0.1358	0.1204	0.0554	0.0000	0.0000	0.0000	0.0000	
	4	*11*	*31*	*39*	*52*	*52*	*52*	*52*	**52**
1996	0.0542	0.0260	0.0140	0.1853	0.0962	0.0392	0.0240	0.0000	
	0	*6*	*15*	*32*	*43*	*50*	*51*	*52*	**52**
1997-1998(7)	0.0422	0.0428	0.0892	0.0241	0.0819	0.0202	0.0000	0.0000	
	1	*4*	*18*	*35*	*64*	*78*	*83*	*83*	**83**

Table 2.2: HE_W for 2 Week Hedge Duration

	Basis Size Used in the Decision Rule (Y)								No. Of
	< -40	**< -30**	**< -20**	**< -10**	**< 0**	**< 10**	**< 20**	**< 30**	**Obs.**
Whole Sample	0.0617	0.0625	0.0783	0.0836	0.0566	0.0136	0.0022	0.0000	
	6	*18*	*48*	*84*	*129*	*156*	*166*	*171*	**171**
1992	-0.0939	-0.0939	-0.1109	-0.0516	0.0036	0.0100	0.0000	0.0000	
	0	*0*	*5*	*10*	*17*	*24*	*26*	*26*	**26**
1993	0.3037	0.3037	0.2645	0.3528	0.2212	0.0000	0.0000	0.0000	
	0	*0*	*3*	*11*	*19*	*26*	*26*	*26*	**26**
1994	-0.0117	0.0134	0.0134	-0.0523	0.0130	0.0575	0.0144	0.0000	
	2	*4*	*4*	*8*	*12*	*18*	*21*	*26*	**26**
1995	0.0248	0.0903	0.1095	0.0660	0.0000	0.0000	0.0000	0.0000	
	3	*7*	*15*	*19*	*26*	*26*	*26*	*26*	**26**
1996	0.0531	0.0135	0.0700	0.1134	0.0592	0.0389	0.0000	0.0000	
	0	*4*	*8*	*18*	*24*	*25*	*26*	*26*	**26**
1997-1998(7)	0.0791	0.0501	0.1050	0.0749	0.0466	-0.0110	0.0000	0.0000	
	1	*3*	*13*	*18*	*31*	*37*	*41*	*41*	**41**

Table 2.3: HE_W for 4 Week Hedge Duration

	Basis Size Used in the Decision Rule (Y)								No. Of
	< -40	**< -30**	**< -20**	**< -10**	**< 0**	**< 10**	**< 20**	**< 30**	**Obs.**
Whole Sample	0.0817	0.0647	0.0647	0.0738	0.0316	0.0092	0.0016	0.0000	
	5	*13*	*31*	*51*	*70*	*77*	*82*	*85*	**85**
1992	-0.0937	-0.0937	-0.1058	-0.0822	-0.1051	-0.0304	0.0000	0.0000	
	0	*0*	*4*	*6*	*9*	*11*	*13*	*13*	**13**
1993	0.3115	0.3115	0.2333	0.3183	0.1307	0.0000	0.0000	0.0000	
	0	*0*	*2*	*5*	*10*	*13*	*13*	*13*	**13**
1994	0.0055	-0.0353	-0.0353	0.0928	0.1079	0.0736	0.0104	0.0000	
	2	*4*	*4*	*7*	*8*	*9*	*10*	*13*	**13**
1995	0.1178	0.0463	0.0736	0.0569	0.0000	0.0000	0.0000	0.0000	
	2	*4*	*9*	*10*	*13*	*13*	*13*	*13*	**13**
1996	0.0449	0.0506	0.0605	-0.0216	0.0054	0.0054	0.0000	0.0000	
	0	*3*	*4*	*11*	*12*	*12*	*13*	*13*	**13**
1997-1998(7)	0.0965	0.0932	0.1280	0.0770	0.0438	0.0074	0.0000	0.0000	
	1	*2*	*8*	*12*	*18*	*19*	*20*	*20*	**20**

Table 3: Time to Expiration Effect on Hedging Performance of Working's Strategy

This table reports the effect of time to expiration of the SPI on HE_W. For each hedge duration, the SPI contracts are divided into groups according to their time to expiration. The time to expiration is measured as number of weeks to maturity counted from the lifting date of the hedge. Three groups of time to expiration are studied, 0-4, 5-8, and 9-13 weeks to expiration. The numbers shown in the table are HE_W's for each time to expiration group and each Y (the basis size used in the decision rule).

Weeks	Basis Size Used in the Decision Rule (Y)							
to Expiration	< -40	< -30	< -20	< -10	< 0	< 10	< 20	< 30
1 Week Hedge Duration								
0 - 4	0.0459	0.0658	0.0950	0.1003	0.0123	0.0397	0.0240	0.0000
5 - 8	0.0163	0.0196	0.0553	0.1159	0.0702	0.0033	0.0029	0.0000
9 - 13	0.1037	0.0812	0.0766	0.0985	0.1373	0.0550	0.0173	0.0037
2 Week Hedge Duration								
0 - 4	0.0277	0.0538	0.0512	0.0715	0.0389	0.0066	0.0000	0.0000
5 - 8	0.0421	0.0370	0.1093	0.0945	0.0735	0.0272	0.0080	0.0000
9 - 12	0.1507	0.1099	0.0882	0.0905	0.0675	0.0089	-0.0013	0.0000
4 Week Hedge Duration								
0 - 4	0.0564	0.0654	0.0766	0.0875	0.0349	0.0099	-0.0012	0.0000
5 - 8	0.1139	0.0427	0.0214	0.0069	0.0084	0.0127	0.0073	0.0000
9 - 12	0.1569	0.1569	0.1569	0.2565	0.1067	-0.0139	0.0000	0.0000

Table 4: The Hedging Effectiveness of Variance Minimization Model (HE_E)

Tables 4.1, 4.2, and 4.3 report the HE_E for 1,2, and 4 week hedge duration, respectively. The HE_E is calculated from equation *9*:

$$HE_E \quad = \quad [s^2_{Rs} - s^2_h] \; / \; s^2_{Rs}$$

The italic numbers underneath each HE_E are the average hedge ratios from the Variance Minimization model (ie. Equation (8)). The column denoted "Naïve Hedge" shows HE_E when s^2_h is obtained from using b = 1 hedge ratio. The column denoted "Fixed Hedge" shows HE_E when the whole sample data is used to calculate $[s_{Rs,Rf} / s^2_{Rf}]$. Hedge ratios for the whole sample period are then based on this value. The column denoted "Updated Hedge" reports HE_E when 1 year data is used to calculate $[s_{Rs,Rf} / s^2_{Rf}]$. The hedge ratios of that particular year are then based on this value. The column denoted "Rolling Hedge" shows HE_E when we use 1 year data to calculate $[s_{Rs,Rf} / s^2_{Rf}]$, then the hedge ratios for the next year are based on this value.

Table 4.1: HE_E for 1 Week Hedge Duration

	Naïve	**Fixed Hedge**	**Updatd Hedge**	**Rolling Hedge**	**No. Of Obs.**
Whole Sample	0.8839	0.9244	0.9305	0.9272	*343*
		0.8258	*0.8266*	*0.7951*	
1992	0.8422	0.8988	0.9001		*52*
		0.8269	*0.7968*		
1993	0.8885	0.9279	0.9279	0.9266	*52*
		0.8262	*0.8276*	*0.7961*	
1994	0.8272	0.9210	0.9311	0.9206	*52*
		0.8290	*0.7503*	*0.8304*	
1995	0.8272	0.9134	0.9191	0.9186	*52*
		0.8207	*0.7584*	*0.7428*	
1996	0.9248	0.9676	0.9676	0.9621	*52*
		0.8251	*0.8239*	*0.7625*	
1997-98/7	0.9312	0.9217	0.9348	0.9214	*83*
		0.8267	*0.9370*	*0.8255*	
No. Of Obs.	*343*	*343*	*343*	*291*	

Table 4.2: HE $_E$ for 2 Week Hedge Duration

	Naïve	Fixed Hedge	Updatd Hedge	Rolling Hedge	No. Of Obs.
Whole Sample	0.9134	0.9390	0.9419	0.9376	*171*
		0.8565	*0.8506*	*0.8239*	
1992	0.8834	0.9131	0.9132		*26*
		0.8574	*0.8615*		
1993	0.9045	0.9448	0.9465	0.9444	*26*
		0.8571	*0.8207*	*0.8611*	
1994	0.8516	0.9107	0.9172	0.9159	*26*
		0.8604	*0.7924*	*0.8239*	
1995	0.9107	0.9493	0.9499	0.9469	*26*
		0.8511	*0.8273*	*0.7838*	
1996	0.9298	0.9733	0.9750	0.9748	*26*
		0.8551	*0.8191*	*0.8313*	
1997-98/7	0.9376	0.9354	0.9421	0.9279	*41*
		0.8573	*0.9344*	*0.8212*	
No. Of Obs.	*171*	*171*	*171*	*145*	

Table 4.3: HE $_E$ for 4 Week Hedge Duration

	Naïve	Fixed Hedge	Updatd Hedge	Rolling Hedge	No. Of Obs.
Whole Sample	0.9464	0.9600	0.9651	0.9456	*85*
		0.8916	*0.8701*	*0.8321*	
1992	0.9255	0.9251	0.9288		*13*
		0.8929	*0.9532*		
1993	0.9208	0.9351	0.9353	0.9289	*13*
		0.8931	*0.8801*	*0.9535*	
1994	0.8966	0.9497	0.9650	0.9534	*13*
		0.8941	*0.7898*	*0.8811*	
1995	0.9496	0.9771	0.9786	0.9721	*13*
		0.8868	*0.8476*	*0.7832*	
1996	0.7712	0.8415	0.8767	0.8577	*13*
		0.8906	*0.7393*	*0.8512*	
1997-98/7	0.9810	0.9767	0.9819	0.9296	*20*
		0.8921	*0.9615*	*0.7405*	
No. Of Obs.	*85*	*85*	*85*	*72*	

Table 5: The Effects of Estimation Period Length on HE_E and Hedge Ratio (b*)

The table reports Hedging Effectiveness of the Variance Minimization model (HE_E) and its hedge ratio (b*) when moving window procedure is used. Different window sizes (or estimation period lengths) are used for the estimation of $[s_{Rs,Rf} / s^2_{Rf}]$, which is, then, used to obtain b*'s. For each hedge duration, the effects of estimation period length on HE_E and b* are studied in both ex post and ex ante setting.

Window	Ex Post		Ex Ante		No. Of Obs.
Size	HE_E	*b**	HE_E	*b**	in 1 Window
1-week Hedge Duration					
4	0.9449	0.8330	0.8885	0.8329	*4*
8	0.9445	0.8218	0.9281	0.8218	*8*
13	0.9434	0.8213	0.9313	0.8211	*13*
26	0.9378	0.8210	0.9285	0.8207	*26*
39	0.9333	0.8223	0.9256	0.8219	*39*
52	0.9341	0.8187	0.9283	0.8181	*52*
2-week Hedge Duration					
6	0.9496	0.8458	0.9261	0.8458	*3*
8	0.9335	0.8443	0.9175	0.8440	*4*
12	0.9496	0.8458	0.9261	0.8458	*6*
24	0.9476	0.8448	0.9362	0.8448	*12*
36	0.9446	0.8472	0.9341	0.8471	*18*
52	0.9443	0.8464	0.9372	0.8458	*26*
4-week Hedge Duration					
12	0.9398	0.7780	0.8847	0.7794	*3*
16	0.9591	0.7871	0.9222	0.7891	*4*
24	0.9639	0.8255	0.9377	0.8254	*6*
36	0.9693	0.8551	0.9556	0.8555	*9*
52	0.9716	0.8637	0.9594	0.8633	*13*

Table 6: Time to Expiration Effect on HE_E and Hedge Ratios (b^*)

This table reports the effect of time to expiration of the SPI on HE_E and b^*. For each hedge duration, the study is done by means of equation *(13)*;

$$R_{s,t} \quad = \quad b_0 + b_1 R_{f,t} D_0 + b_2 R_{f,t} D_1 + \ldots\ldots + b_{n+1} R_{f,t} D_n + e_t$$

The regression is run using White's heteroscedasticity consistent covariance.

Table 6: Time to Expiration Effect on Hedge Ratios

Weeks to Expiration	Beta$_i$	t-stat	S/F[b]	*b**	HE$_E$	No. of Obs.
1-week Hedge *R^2 = 0.9290*						
0	0.8499	14.6906	0.9992	0.8492	0.8987	26
1	0.8289	18.2885	0.9987	0.8278	0.9141	26
2	0.7841	20.0715	0.9978	0.7823	0.9347	26
3	0.8957	14.8558	0.9970	0.8931	0.9352	26
4	0.8189	19.4812	0.9964	0.8159	0.9299	26
5	0.8375	62.7872	0.9962	0.8343	0.9826	26
6	0.8621	25.4244	0.9962	0.8589	0.9477	26
7	0.8091	22.4618	0.9953	0.8053	0.9262	26
8	0.8767	13.5585	0.9936	0.8711	0.8852	27
9	0.9663	7.4925	0.9935	0.9601	0.9192	27
10	0.7393	21.9613	0.9936	0.7345	0.9426	27
11	0.7794	18.5160	0.9933	0.7741	0.9170	27
12	0.7999	24.7512	0.9919	0.7934	0.9241	25
2-week Hedge *R^2 = 0.9401*						
0	0.8420	23.6743	0.9984	0.8406	0.9479	26
2	0.8778	19.0932	0.9966	0.8748	0.9417	26
4	0.8767	25.5301	0.9966	0.8737	0.9481	26
6	0.8580	21.0354	0.9942	0.8530	0.9028	26
8	0.8964	9.8594	0.9942	0.8912	0.9230	27
10	0.8701	27.2733	0.9916	0.8627	0.9544	27
12	0.7956	25.6964	0.9946	0.7913	0.9796	13
4-week Hedge *R^2 = 0.9624*						
0	0.9345	35.4633	0.9961	0.9309	0.9792	26
4	0.8783	17.2962	0.9938	0.8728	0.9315	26
8	0.9168	15.8267	0.9904	0.9080	0.9653	27
12	0.7779	21.9774	0.9960	0.7748	0.9739	6

[a] t-stat of each b_i.

[b] Average of S_t/F_t for each Week to Expiration group.