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Futures Contracts Optimal Hedge Ratio in Iran Mercantile Exchange (IME): Generalized Semi Variance (GSV) based approach

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ABSTRACT

In this article, GSV based optimal hedge ratios for Bahar-e-Azadi gold coin futures contracts traded in Iran Mercantile Exchange (IME) are estimated and compared with Minimum Variance (MV) optimal hedge ratio. The empirical results indicate that GSV optimal hedge ratios are smaller than MV and also with increase in risk aversion degrees, primarily increased and then decreased; While MV optimal hedge ratio because of lack of notice to risk aversion issue, in all levels of risk aversion is fixed. Finally findings show that amount of target return is an important parameter in optimal hedge ratio variability with change in risk aversion degree.

JEL Classification: G13
KEYWORDS: Optimal Hedge Ratio, Futures Contract, Generalized Semi Variance (GSV), Lower Partial Moment (LPM), Iran Mercantile Exchange (IME)

INTRODUCTION

One of the main functions of futures contracts is reducing the risk of price fluctuations. There is extensive literature on the computation of optimal hedge ratio, using different methods. Optimal hedge ratio is the number of futures contracts which a person must hold to cope with the underlying asset price volatility in the spot market. It is necessary for the hedger and investors to calculate this ratio precisely, in order to avoid over-hedging or under-hedging. Over-hedging is a situation in which a person holds futures contracts more than the amount needed to hedge, which results in increasing the cost of hedge due to higher margin requirements. On the other hand, taking insufficient number of futures positions (under-hedging) will expose his underlying asset to risk. Therefore determination of optimal hedge ratio is one of the major requirements of an effective hedge strategy.

The methods for deriving the hedge ratio will be categorized into two groups which are risk-minimizing and utility maximizing .In the risk minimizing methods, we try to derive the optimal hedge ratio in a way to minimize risk by setting a criterion for it. The tradition risk measurement criterion is Variance which is calculated the optimal hedge ratio by minimizing it. The optimal hedge ratio which is calculated by this method is called Minimum Variance (MV) hedge ratio.

The MV method is desirable in empirical aspects because of easy calculation but it has theoretical disadvantages which is raised the need to alternatives for deriving optimal hedge ratio.

MV method considers implicitly that returns of spot and futures prices jointly are normally distributed and the investors have quadratic utility function. While, based on the many evidence, the assumption of normally distributed does not always hold as well as quadratic utility function assumption is too restrictive. To remedy these deficiencies, Cheung Kwan & Yip (1990) showed that, if the considered criterion for risk measuring has the stochastic dominance, then there is no need to consider returns normally distributed as well as definite form of utility function.

Also in MV method, variance is a two-sided risk criterion, which means that positive or negative volatility will consider as risk. Adams & Montesi (1995) found that corporate managers are concerned with variability in losses more than the variability in profits that this finding is consistent with the Mao (1970). In other words, from the view point of corporate managers, risk is to not being succeed in achieving the target return; the subject that is consistent with a firm's treasurer while he use futures contracts to prevent losses because of currency rate fluctuations or any other variables. Some theorists call loss fluctuations "downside risk" and changes in profit are called "upside potential", that if this definition of risk will be accepted, hedging could decrease the downside risk instead of variance or standard deviation. One of the appropriate tools for measuring downside risk is introduced by Fishburn (1977) which Bawa entitled it as Lower Partial Moment (LPM). In this criterion, risk is measured by a probability-

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weighted power function of the shortfalls from a specific target return. This power is called order of LPM and bigger LPM order shows that the individual has greater risk aversion in facing greater risks.

Based on this definition of risk, we can derive optimal hedge ratio in a way that minimize LPM, this method is called GSV (Generalized Semi Variance) by Chen et al. (2001). Beside the consistency of LPM criterion with the corporate managers risk definition, this criterion theoretically has some advantage because minimization of LPM is consistent with the expected utility hypothesis.

When an underlying asset has the possibility to hedge by use of options and futures contracts simultaneously, it seems that options contracts will be the more powerful tool for decreasing the downside risk as large losses and even eliminate this kind of risk. But the considerations of small and medium losses (or gains short of the target return) in calculating LPM, however, rebut the above conclusion. There are lots of evidences which show that futures contracts are more successful in decreasing the downside risk, comparing to option contracts. Some of researches also believe that corporate managers, prefer futures to options contracts because of low hedging costs.

As mentioned above, there is other category of methods to deriving optimal hedge ratio which are known as utility maximizing methods. The main problem of the risk minimizing methods (without considering the efficiency of risk measurement criterion) is that in this methods we assume that the investor is only cares about his risk and investing return is not important for him; while this is not true for investors who are interested in both, minimizing risk and maximizing investing return. Utility maximizing methods are raised to remedy this deficiency and try to maximize the investing return by considering the utility function besides minimizing investment risks. Mean-GSV (M-GSV) method is belonged to utility maximizing group of methods.

In this article, we investigate the issue of price fluctuations hedging with Bahar-e-Azadi gold coin futures contracts which are traded in Iran Mercantile Exchange (IME). The first futures contract was traded in Iran in 2007 with gold coin as underlying asset.

In this article we will estimate GSV and M-GSV optimal hedge ratios and compare them with MV optimal hedge ratio. GSV and M-GSV optimal hedge ratios depend on two parameters. First target return and second LPM order. Optimal hedge ratio will be calculated by considering different values as target return and risk aversion degrees, while MV optimal hedge ratio will be the same in all cases.

Lower Partial Moment (LPM)

Consider a representative investor which has an asset portfolio that return of the portfolio is a random variable X. Let $F(.)$ denote the probability distribution function of X. The n-th order LPM of X will be defined in this formula:

$$l(c,n,X) = \int_{-\infty}^{c}(c-X)^n dF(X) \quad (1)$$

Where c is the target return. Regarding to this function, when the return of the investor portfolio is bigger than his target return, there will be no risk for him and the risk appears when returns falling short of c. If the target return is bigger, it shows an investor who has higher expectations from his investment. Also the n determines the reaction of investor while facing with loss, when n is bigger, it shows a person who is more risk averse when facing loss, and assigns greater weights to these losses.

If the value of risk aversion equals to 2 ($n = 2$) and target return considered as zero ($c = 0$), we obtain the semivariance of X (mean=0) which is used by Markowitz (1959) as a risk measurement criterion instead of variance and standard deviation.

The risk measurement criterion which is introduced by Fishburn (1977) is the same as function (1), but n can only get rational values. Some of LPM properties are listed below.

1- For a given pair of c and n, LPM is uniquely determined by the probability distribution function. That is, if X_1 and X_2 have the same distribution, then:
$l(c,n,X_1) = l(c,n,X_2)$

2- As c increases, LPM also increases. That is, when $c_1 > c_2$ (2)

$$l(c_1,n,X) > l(c_2,n,X) \quad (3)$$

3- If the density function of X is symmetric at c then

$$l(c,2,X) = {}^{Var(X)}/_{2} \quad (4)$$

And $Var(X)$ is the variance of X.

In order to incorporate hedging decision using futures contracts into the framework, we consider a person (investor) who has W_0 as his initial amount of wealth and a nontrade able spot position Q at time 0. The person keeps kQ number of futures contracts in order to hedge his own risk. If there is only one risk hedging and Δp considered as spot price changes as well as Δf would be changes in futures price, then the wealth of the investor in the ending of time 1 will be equal to

$$W_1 = W_0 + (\Delta p + k\Delta f) = W_0 + (\mathrm{r_p} + \theta \mathrm{r_f})\mathrm{p_0 Q} \tag{5}$$

Which $\mathrm{p_0}$ is the spot price in time 0 and $r_\mathrm{p} = {}^{\Delta \mathrm{p}}/_{\mathrm{p_0}}$ and $r_\mathrm{f} = {}^{\Delta \mathrm{f}}/_{\mathrm{f_0}}$ are the spot and futures returns respectively. Also $\mathrm{f_0}$ is the futures price in time 0. Optimal hedge ratio is $\theta = {}^{kf_0}/_{\mathrm{p_0}}$ which based on expected utility hypothesis, the investor chooses the value of θ in a way that maximize his utility , while in GSV method, we want to calculate the θ who can minimize LPM criterion. Bawa (1975, 1978) and lien & TSE (1997) showed that both contents are the same in the hedge framework. We can find the optimal hedge ratio through GSV method (LPM minimizing) which is synced with utility maximizing.
Suppose target return is c, the *n*-th order LPM of $(m = r_p + \theta r_f)$ is equal to:

$$l(c, n, m) = E\left[\left(\max(0, c - r_p - \theta r_f)\right)^n\right] \tag{6}$$

And $E(.)$ is the expectations operator. when LPM order is bigger than 1, optimal hedge ratio θ satisfy below first order condition

$$-nE\left[\left(\max(0, c - r_p - \theta r_f)\right)^{n-1} r_f\right] = 0 \tag{7}$$

We can show that the second order condition is always satisfied. The main problem in the upper mentioned function is that θ cannot be calculated or estimated using common econometrics approaches and we should use numerical methods in order to calculate optimal hedge ratio. Because for LPM calculation is needed to know distribution function of spot and futures returns. In other words for each value of θ we need to specify the m distribution function. In order to solve this problem, some of the researchers calculated empirical distribution of m using historical data. Also in some other articles estimated distribution function using Gausssian Kernel method which Reiss (1981) has proved that this method is more efficient than empirical distribution method.

As it is mentioned above, GSV optimal hedge ratio has some problems because of lack of attention to investment return. In order to solve this, Chen et al. (2001) developed the GSV method by considering investment return and its risk.
Utility function is considered as:

$$U(R_h) = E(R_h) - V_{\delta,\alpha}(R_h) \tag{8}$$

Where $E(R_h)$ is expected return and $V_{\delta,\alpha}(R_h)$ is the LPM criterion for calculation of investment risk .It is clear that, the risk aversion parameter is not explicit in utility function but it is considered implicitly in LPM criterion.

Moreover, in comparison with GSV method, M-GSV is a better method, regarding the returns beside risk as well as it has some statistical advantages. As we have mentioned, GSV criterion has random dominance property and it is better than MV method in this respect, but we can show that optimal hedge ratios which is calculated by GSV method has not this desirable property, because it is needed that, GSV optimal hedge ratio will be independent from target return c, but we can prove that with changing of c will be changed optimal hedge ratio .If instead of GSV we use M-GSV for deriving optimal hedge ratio, mentioned restriction will be resolved.

If the futures prices follow pure martingale process (expected return of futures prices is equal to zero), M-GSV and GSV methods optimal hedge ratios will be equal. Lien & TSE showed that, if futures prices follow pure martingale process and spot and futures prices jointly normally distributed then M-GSV optimal hedge ratio will be equal to MV, because if the futures prices follow pure martingale process, GSV and M-GSV optimal hedge ratios will be the same and if beside this, spot and futures returns have jointly normal distribution, MV hedge ratio will be equal to them.

Data Description

Data used in this article, are futures and spot prices for Bahar-e-Azadi Gold Coin which its spot prices acquired from Tehran Union of Manufacturers and Sellers of Gold and futures prices from Iran Mercantile Exchange (IME) website. The issue that should consider in using futures prices is that, in each time, there are some tradable contracts, which are different maturity date.

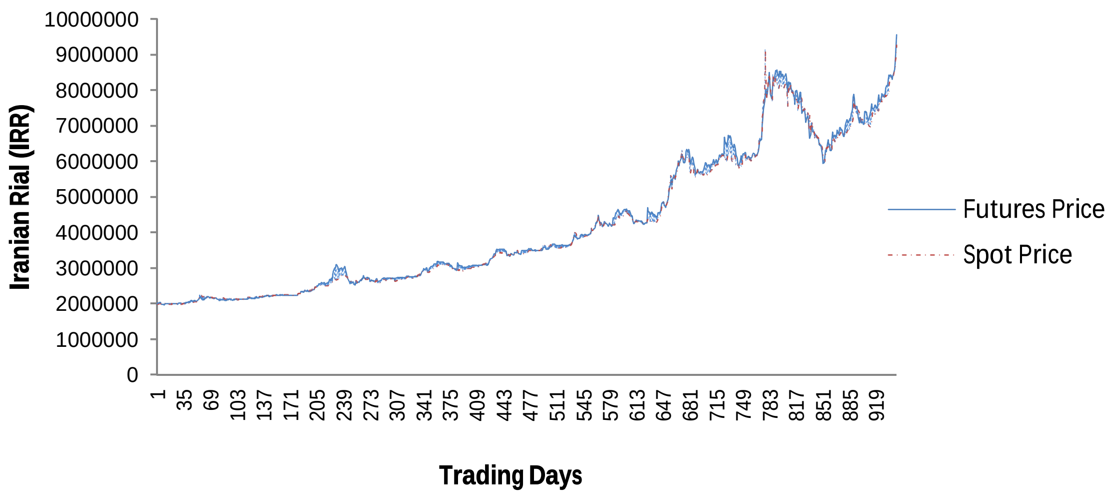
So, contrary to spot prices, which there are only single price for asset at any time, there are different futures prices for underlying asset and only one contract should be choose as futures prices.

Review of researches shows that traditionally, price of first maturity futures contract considered as futures price and when reaching to the maturity of the contract, it is transferred to the next maturity contract and its prices will be futures prices.

Futures prices are the daily settlement prices of the contracts which are calculated according to IME regulations in ending hours of trading days. The existed complexity in using futures prices is that with maturing the current contract, we must use next maturity data and usually in this method we observe an anomalistic Jump in prices .In order to remedy this problem, various solutions are used in studies and we have used in our paper roll over method.

Data used are futures and spot prices for Bahar-e-Azadi Gold Coin from November 25, 2007 to September 10, 2012 which include 945 observation. The trend for futures and spot prices in mentioned period are shown in figure 1.

Figure 1. Gold coin Spot and Futures prices from November 25, 2007 to September 10, 2012



According to this subject that needed variables for estimation of optimal hedge ratio are spot and futures returns, in table 1 some statistical specification of these variables were presented. In order to calculate the return of the prices, formulas (9) and (10) were used.

$$r_p = Ln\left(\frac{P_t}{P_{t-1}}\right) \quad (9)$$

$$r_f = Ln\left(\frac{F_t}{F_{t-1}}\right) \quad (10)$$

Where P_t is spot price and F_t is futures price of asset in time t.

Table 1. Summary Statistics of the Spot and Futures Price Return

	Spot Price Return	Futures Price Return
Number of observations	944	944
Mean	0.001664	0.000901
Medium	0.000000	0.000623
Maximum	0.158349	0.048617
Minimum	-0.134312	-0.047126
Standard Deviation	0.014868	0.012934
Skewness	0.979722	0.090290
Kurtosis	28.29060	4.462601
Jarque-Bera	25309.19	85.42460

Table 1 shows that the return of spot and futures prices of Bahar-e-Azadi Gold Coin has not normal distribution and so MV and GSV based optimal hedge ratios will be different from each other. Also as discussed above, if futures prices follow pure martingale process, then GSV and M-GSV optimal hedge ratios will be equal. From viewpoint of statistics, pure martingale process is means that expected return of futures prices is equal to zero. In order to investigate the existence of this process we use $t$statistic:

$$t = \frac{E(r_f)-0}{SD_{r_f}} \qquad (11)$$

$$t = \frac{0.000901-0}{0.012934} = 0.06966 \qquad (12)$$

which $E(r_f)$ is the mean of futures prices return and $SD_{r_f}$is standard deviation.

We can initialize that because of relatively high standard deviation value of futures prices return comparing its mean (almost close to zero), we cannot reject the hypothesis being equal to zero for futures prices return and it is recognized that futures prices follow pure Martingale process, so GSV and M-GSV optimal hedge ratios will be the same and cannot be compared with MV separately.

Empirical Results

Before the estimation of GSV and MV optimal hedge ratios, we need to decide about two parameters; LPM order n and target return c. In this article, we use two methods in order to determine target return c. First, mean of spot return is calculated and considered as target return ($c = E(r_P)$) and second, target return will be equal to zero ($c = 0$). Therefore, GSV optimal hedge ratio will be estimated for both return values. To determine LPM order or the risk aversion degree n, shall also be considered this fact that conventional assumption in utility functions that include risk aversion is that, acceptable risk aversion degree must be less or equal to 2 ($n \leq 2$). Despite that, in this article optimal hedge ratio for degrees of higher than 2 will be estimated. The purpose of doing this is that, we find out, with the increase of risk aversion degree the optimal hedge ratio converge to which amount and how will be its relationship with MV optimal hedge ratio which is fixed for all levels of risk aversion.

To estimate MV optimal hedge ratio, different econometric approaches were described in various articles. MV optimal hedge ratio which is estimated by three different econometric approaches include OLS, VAR and VECM are reported in table 2.

Table 2. MV optimal hedge ratio estimated by OLS, VAR and VECM approaches

	VECM	VAR	OLS
MV optimal hedge ratio	-0.644533	-0. 602144	-0.608547

We have used R software in order to calculate LPM and estimate GSV optimal hedge ratio. The estimation results for GSV optimal hedge ratio are presented in figures 2 and table 3.

Table 3. GSV optimal hedge ratio for different risk aversion degrees and target returns

LPM order (Risk Aversion Degree)	$^*c = E(R_S)$	$c = 0$
1.25	-0.4926	-0.4893
1.5	-0.4926	-0.4893
2	-0.5027	-0.5022
3	-0.5086	-0.5114
4	-0.5088	-0.5157
5	-0.5012	-0.5130
6	-0.4835	-0.5018
7	-0.4532	-0.4803
8	-0.4072	-0.4453
9	-0.3427	-0.3930
10	-0.2603	-0.3211
11	-0.1657	-0.2322
12	-0.0677	-0.134
13	0	-0.0354
14 and upper	0	0

Note: $\boldsymbol{E(R_S)}$ is mean of spot price return and is equal 0.001664 as reported in table 1.

Figure 2. GSV and MV optimal hedge ratios for different risk aversion degrees and target returns

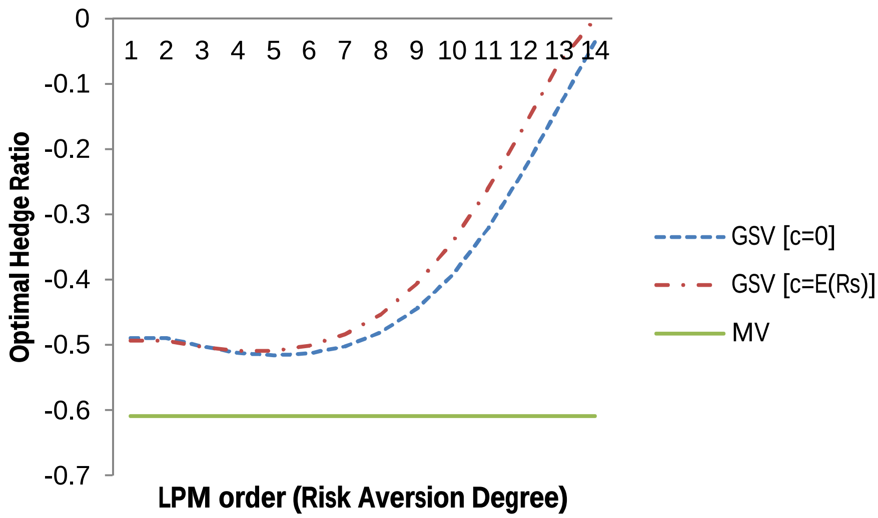


Table 3 and figure 2 have some useful information about the GSV optional hedge ratio and its differences with MV. First, GSV optimal hedge ratio with two target return are less than MV optimal hedge ratio, so it suggests less number of futures contracts in order to hedge. Therefore, the person who use MV optimal hedge ratio, is forced to pay a higher amount because of the higher quantity of futures contracts margin requirements.

As it is pointed out, in MV method we measure the risk by variance which is considers both above and below mean return to be risky while, in GSV we use LPM to calculate risk which considers only below mean return as risk, so it is logical that in all levels of risk aversion, GSV optimal hedge ratio would be smaller than MV. Second, with increase of risk aversion degree, GSV optimal hedge ratio primarily increases and then decreases.

For interpreting this finding we must point to the fact that according to microeconomics principles, risk aversion degrees which are higher than 2 are not acceptable so the decrease of optimal hedge ratio in high risk aversion levels seems non-logical. The third is that, GSV optimal hedge ratio, with two target return $c = 0$, $c = E(R_S)$ are almost equal for low risk aversion degrees but with the increase of risk aversion levels, GSV optimal hedge ratio with the expected return $c = E(R_S)$, will suggest lower numbers of futures contracts in comparison with target return $c = 0$ for hedging. So, in the acceptable degrees of risk aversion, practically it is not different for the hedger to choose which of the target returns.

Although two GSV optimal hedge ratios for $c = 0$,and $c = E(R_S)$ target returns in acceptable degree of risk aversion are same but one important point is the rhythm of changes for optimal hedge ratio with the changes in levels of risk aversion.

As it is shown in table 3, with target return $c = 0$ and increase of risk aversion from 1.5 to 2 it's seems that, optimal hedge ratio will increase from -0.4893 to -0.5022 (2.63 percent) and in the case of increase of risk aversion level from 2 to 3 the growth from -0.5022 to -0.5114 (1.83 percent) while with expected return of $c = E(R_S)$ increases were not too much and was from -0.4926 to -0.5027 (2.03 percent) and -0.5027 to -0.5086 (1.17 percent). So GSV optimal hedge ratio with target return $c = 0$ is more sensitive to change in risk aversion degree rather than $c = E(R_S)$ one.

SUMMARY AND CONCLUSION

Minimum Variance (MV) optimal hedge ratio which uses variance as criterion for risk measurement amid simplicity of calculations and its empirical advantages, it is based on some unrealistic and restrictive assumptions.

To remedy these disadvantages, other methods were introduced for deriving optimal hedge ratio which other criterion are used to measure risk. GSV and M-GSV methods are examples of these methods which use LPM criterion to risk measurement. LPM contrary to variance which regards positives and negatives fluctuations as risk, shortfall of return from expected (target) return will be considered as risk.

In this article, MV, GSV and M-GSV optimal hedge ratios are estimated for Bahar-e-Azadi Gold Coin futures contracts traded in Iran Mercantile Exchange (IME). Regarding to the fact that, futures prices follow pure Martingale process, GSV and M-GSV hedge ratios are equal to each other. Results shows that, optimal hedge ratio from GSV method for both target returns are less than MV so fewer number of futures contracts will be suggested for hedging.

Also, with the increase of risk aversion levels, GSV optimal hedge ratio primarily will increase and then decrease while optimal hedge ratio in MV method will be the fixed for all risk aversion degrees. Finally GSV optimal hedge ratio with target return $c = 0$ and $c = E(R_S)$for the low levels of risk aversion will be approximately equal to each other but, with the increase of risk aversion, the optimal hedge ratio with the target return $c = E(R_S)$, fewer number of futures contracts will be suggested with the target return of $c = 0$ for hedging.

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