The Minimum Semivariance Hedge for Food Manufacturers in Korea

by

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I. Introduction

Price uncertainty is perhaps the most difficult factor to handle in the decision-making process for most economic agents. The economics of uncertainty says that firms facing price uncertainty reduce the production level when there is no proper means of risk management (Sandmo; Turnovsky). Efforts to manage price risk include diversification, vertical integration, crop insurance, contract production, and forward contracts. However, hedging with futures contracts is regarded as the most effective and cost-efficient.

A conventional method of hedging is the mean-variance approach, which maximizes the expected profit net of the risk premium. Under the assumption of market efficiency, the minimum variance hedge is also used. While these methods employ rather strong assumptions (Stein; Lence), they are still popular to both academic researchers and practitioners because of its easiness to use.

However, the concept of variance (or standard deviation) that is used as a measure of risk in the MV approaches has problems in logical and empirical aspects. The total variance considers both sides of variability, upside and downside variability, as unfavorable and measure them as risk. That is, values of both greater than and less than the average are regarded as risk. Thus, the conventional variance minimizing approaches assume that hedgers are willing to forgo positive potential profits to reduce total variance.

In practice, however, risk-averse decision makers tend to define risk as the chance of failing to meet a target level of return (Mao; Markowitz; Lanzilotti; Hogan and Warren 1972, 1974). Adams and Montesi (1995) assert that corporate managers are concerned more about
variability in losses, but not so much about variability in gains.¹) This finding is not compatible with the definition of variance.

To overcome such problems, Markowitz (1959) and Mao (1970) developed the concepts of semivariance. The semivariance is defined as the expected value of squared unwanted deviations from a target level, i.e., $S = E \left[ \min (R - T, 0) \right]^2$, where $E$ is the expectation operator, $R$ is a random variable, and $T$ is the target level. Thus, the semivariance measures only unwanted variability as risk, excluding favorable variability.

The concept of semivariance about a target level has been used in the past research. Bawa (1975, 1978) proposed the concept of LPM (Lower Partial Moment), which reflect downside risk as well as larger aversion to larger losses, and showed that the minimization of LPM is consistent with the expected utility approach. Lee and Rao (1988) developed a capital asset price model in a LPM framework. Skelton and Turvey (1994) adopted semivariance in a portfolio selection model applied to agriculture. More recently, Lien and Tse (1998) derived the minimum LPM hedge ratios using a time-varying conditional heteroskedasticity model of the spot and futures returns. Nayak and Turvey (1998) estimated the minimum semivariance hedge (MSVH) ratios for Canadian corn yield and concluded that this approach reduced more downside risk with less hedging compared to the conventional MV hedge.

The purpose of this paper is to examine the performance of the MSVH as an alternative to the MVH for the food manufacturers in Korea, who import U.S. corn and soybeans as inputs for their final products. They face two risks: price risk and exchange rate risk. The price risk can be hedged at CBOT. With the introduction of the Korea Futures Exchange (KOFEX) in April 1999, the won/dollar exchange rate risk can be hedged with futures. Because of its short existence, however, data are not just enough for a simulation analysis for this study.²) Thus, we
assume no hedging opportunity for the exchange rate risk. Once the hedge ratios are estimated, hedge effectiveness is estimated and compared among the alternatives.

The results of this study shows that the MSVH effectively reduces the price risk defined as either semivariance or variance, using less futures contracts than the MVH does. However, the semivariance reduced is greater with the MVH than with the MSVH, which is not consistent with Nayak and Turvey (1998). Considering the cost involved with hedging, the MSVH seems to be an efficient strategy to use.

II. Model Framework

The profit of a typical food manufacturer in Korea who uses import grains as an input can be defined as \( \pi = p q - p g G - p o O \), where \( p \) is the price of the final product \( q \) in the local currency, \( G \) and \( O \) are the quantities for grain and all other inputs, respectively, and \( p_g \) and \( p_o \) are relevant input prices in the local currency. Suppose that the grain is separable to all other inputs in production technology, and that \( p, q, p_o, \) and \( O \) are fixed or constant. Then the grain price is the only source of risk, and the profit maximization will be equivalent to the minimization of the procurement cost defined as:

\[
(1) \quad C = p_g G,
\]

The anticipatory hedgers as in this study place a long position in period 1, which will be liquidated later on in period 2. Since there is no grain purchased in period 1, only current futures price, and the basis at the terminal period matter. The cost faced by food manufacturers in period 2 when the grain input is purchased for production can be expressed as equation (2):
\( (2) \quad C = p_g G - (p_f - p_f^0) F, \)

where \( F \) is the size of futures contracts bought, \( p_f^0 \) is the known futures price at period 1, and \( p_g \) and \( p_f \) are the random cash and futures price at the terminal point of hedge, respectively. As is well known in the literature, the MVH ratio is

\( (3) \quad b = \frac{F}{G} = \frac{\text{Cov}(p_f, p_g)}{\text{Var}(p_f)}. \)

Witt, Schroeder, and Hayenga (1987) shows that the price level model is relevant for anticipatory hedges.

**Derivation of the Minimum Semivariance Hedge Ratio**

If the food manufacturers under consideration concern only the downside risk, then the semivariance is the relevant measure of risk, which is defined as

\( (4) \quad E \left[ \max (C - T, 0) \right]^2, \)

where \( C \) is a stochastic procurement cost defined in equation (2) and \( T \) is a target cost.

Following Nayak and Turvey (1998), let

\( (5) \quad C_T = \begin{cases} C & (C > T) \\ T & (C \leq T) \end{cases}. \)

Then the semivariance of the procurement cost \( S_{C_T}^2 \) can be redefined as:

\( (6) \quad S_{C_T}^2 = E[C_T - T]^2 = E[C_T + \epsilon_{C_T} - T]^2 \\
= E[C_T^2 + \epsilon_{C_T}^2 + T^2 + 2C_T \epsilon_{C_T} - 2C_T T - 2\epsilon_{C_T} T] \\
= C_T^2 + T^2 - 2C_T T + \sigma_{C_T}^2 \\
= (C_T - T)^2 + \sigma_{C_T}^2. \)
where $\overline{C_T}$ and $\sigma_{C_T}^2$ are the expected value and the variance of $C_T$, respectively, and $\varepsilon_{C_T}$ is the unknown stochastic variable with zero mean and variance $\sigma_{C_T}^2$.

Since the procurement cost $C$ is composed of two stochastic parts, cash cost $g$ ($g = \overline{g} + \varepsilon_g$) and the corresponding futures payoff $f$ ($f = \overline{f} + \varepsilon_f$), the variable $C_T$ can be rewritten as

$$C_T = \begin{cases} g + hf & (g + hf > T) \\ T & (g + hf \leq T) \end{cases},$$

where $h$ is the hedge ratio.

Thus, substitution of equation (7) in (6) results in an expression for the semivariance with the two random positions:

$$S_{C_T}^2 = (\overline{C_T} - T)^2 + \sigma_{g_T}^2 + \sigma_{f_T}^2 + 2\sigma_{g_Tf_T},$$

$$= \overline{g}^2 + \overline{f}^2 + T^2 + 2(\overline{g} \overline{f} - \overline{gT} - \overline{fT}) + \sigma_{g_T}^2 + \sigma_{f_T}^2 + 2\sigma_{g_Tf_T},$$

where $g_T = \begin{cases} \frac{g}{Tg} & (g + hf > T) \\ \frac{g + hf}{g + hf} & (g + hf \leq T) \end{cases}$,

$$f_T = \begin{cases} \frac{hf}{Thf} & (g + hf > T) \\ \frac{g + hf}{g + hf} & (g + hf \leq T) \end{cases}.$$

Since equation (8) is not differentiable with respect to $h$, the closed-from expression cannot be derived for the semivariance minimizing hedge ratio. Another problem is that, to obtain $h$, $g_T$ and $f_T$ need to be determined. However, $g_T$ and $f_T$ are a function of $h$ and there is a simultaneity problem. Therefore, an iterative search method should be used to determine the MSVH ratios.
III. Estimation of Hedge Ratios and Validation

Estimation of the MSVH Ratio

Since most empirical studies find hedge ratios less than 1, this study also assumes that the semivariance minimizing hedge ratio is between 0 and 1. Given hedge ratios between 0 and 1 incrementing by 0.01, equation (8) is evaluated, and the MSVH ratio can be obtained, which results in the minimum value of semivariance.

The semivariance is dependent upon the target value $T$, set by the hedger. In general, hedgers want to lock in the cash price at the time of hedge initiation and, thus, the cash price in period 1 is an appropriate choice for the target cost. However, as plural targets result in plural semivariance, the target cost is set with the average cash price during the sample period.

The semivariance also depends on the hedge period because the contingency condition involves a time interval in the futures payoff.

Out-of-Sample Validation

To examine the performance of the MSVH compared to the MVH, hedge effectiveness suggested by Ederington (1979) is used. Since the main objective of hedging is to reduce risk involved in the cash position, this method measures how large is the risk in the hedged position relative to that in the unhedged position. Since this study compares the performance of the MSVH to that of the MVH, the risk is measured with semivariance.

The measure of hedge effectiveness is

$$HE_{sv} = 1 - \frac{\text{semivariance of hedged position}}{\text{semivariance of unhedged position}}.$$  

$HE_{sv}$ approaches one if the hedge is effective. If it is less than zero, the hedge results in more
risk, and is worthless.

This study conducts an out-of-sample validation as in Yang and Kwon (1998), which analyzed the performance of MVH for foreign hedgers using the same data as in this study. They find out that the MVH performs differently according to different hedge periods. That is, the MVHs for less than 15 weeks do not help to reduce price risk, but become effective as the hedge period gets longer. So, the dependence of hedge effectiveness on hedge period is also considered in this study.

For simulation, the sample data are divided into two sub-samples: one for estimation of hedge ratios and the other for validation. The hedge periods considered for validation are one week through 52 weeks by every one week. For each hedge period, hedge effectiveness is measured with the variance or semivariance of the procurement cost in equation (2) from the rolled-over samples. For example, when the first procurement cost with a one-week hedge is evaluated, the sample is rolled over such that the first observation of the sub-sample is dropped and the first observation following the last observation of the sub-sample is added to form a new sub-sample. The hedge ratio is re-estimated and so is the second procurement cost. This process is repeated until the last observation of the validation sample is used. With these costs for a one-week hedge, the semivariance or variance is estimated and compared to that of alternative strategies. This procedure is repeated for up to 52-week hedges.

**Data Description**

This study determines the MSVH ratios for Korean food manufacturers who import U.S. corn and soybeans as inputs and hedges the price risks in CBOT. The spot markets for corn is No. 2 yellow central Illinois, and that for soybeans is No. 1 yellow central Illinois. The data for the futures prices are the CBOT daily closing prices for the nearby contracts from January of 1986 to
December of 1992. The daily prices are converted into weekly average prices. The source of the futures prices is Technical Tools and cash prices are from Dunn & Hargitt. The exchange rate data are from the Korea Foreign Exchange Bank database. The sample period is chosen to compare the results with those in Yang and Kwon (1998). The sample period is divided into two sub-samples: one from 1986 to 1990 for estimation of hedge ratios and the other from 1991 to 1992 for the out-of-sample validation. The sample statistics for the data are summarized in Table 1 and the dynamic movements of the prices along with the exchange rate are illustrated in Figure 1 and 2.

IV. Empirical Results

Estimated Hedge Ratios

Table 2 reports the estimated ratios for MVH and MSVH for the two crops. The MVH ratios are 0.9506 for corn and 0.9771 for soybeans. The MSVH ratios are 0.4269 for corn and 0.4521 for soybeans. Comparing to the MVH, the MSVH requires nearly a half of the futures positions to hedge. These results of small futures positions are consistent with Nayak and Turvey (1998), implying that the MSVH is far less costly.

Hedge Effectiveness

The performance of alternative hedge strategies compared to no hedge is evaluated by hedge period. Figure 3 and 4 show how much each strategy reduces the risk measured by the semivariance for corn and soybeans, respectively. Even though the hedge effectiveness varies over hedge periods, both rules reduce considerable amount of risk compared to no hedge. Table 3
shows that the semivariance that is reduced by the MVH is 78% on the average, while the MSVH reduces 53% for corn. For soybeans, 66% of semivariance is reduced by the MVH and 61% by the MSVH. Contrary to our expectation, however, the MSVH does not outperform the MVH in reducing the semivariance. But, since the MSVH requires smaller futures position, it costs less for about the same performance.

V. Summary and Conclusions

As an alternative to the conventional measure of risk, this study uses the concept of semivariance, which considers only bad outcomes as risk. The semivariance minimizing hedge is applied to the Korean food manufacturers who import U.S. corn and soybeans as inputs and use the CBOT futures as a means to manage price risks.

The results show that the MSVH can successfully reduce the risk and is more cost efficient compared to the conventional MVH. While the MSVH seems promising as an alternative to the MVH, it is evident that estimation of the MSVH ratio is much more difficult and time-consuming. Markowitz (1959) reported that roughly two to four times as much computing time is required to calculate the semivariance than variance. Even though the advanced computer technology reduces the computing time to a considerable extent, it still is cumbersome and uneasy for many practitioners to use the semivariance minimizing hedges.

This study can be extended in several ways. First, it is well documented in the literature that the distribution of most speculative prices is time-varying (Yang and Brorsen). This suggests time-varying hedge rules (Myers and Johnson; Lien and Tse). Also, the long-run equilibrium between the cash and futures prices (i.e. cointegration) should also be considered for more
effective hedges (Lien). It may not be easy to incorporate these issues in the MSVH models, which is already complex. However, it is worth to consider for completeness.

The companies under consideration face two risks: one is from commodity prices and the other from the won/dollar exchange rate. However, the data for exchange rate futures prices are not sufficient enough for analysis of the double hedging model. Thus, this study models incomplete hedging for commodity price risk only. Extension of this study to model the double hedging will be promising when the data are available.

1) Lee and Rao (1988) defined variability associated with good or above normal returns as “upside potential” and variability associated with bad or below normal returns as “downside risk”.

2) The double hedging model is to be considered when data are fully available.

3) That is, \( g = p_g G \) and \( f = (p_f^0 - p_f) F \).
References


Table 1. Sample Statistics for Price Variables

<table>
<thead>
<tr>
<th>Basic Statistics</th>
<th>Corn</th>
<th>Soybeans</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cash Price (won/bu.)</td>
<td>Futures Price (won/bu.)</td>
</tr>
<tr>
<td>Mean</td>
<td>1667.99</td>
<td>1742.55</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>260.83</td>
<td>241.22</td>
</tr>
<tr>
<td>Median</td>
<td>1695.75</td>
<td>1730.19</td>
</tr>
<tr>
<td>Maximum</td>
<td>2338.49</td>
<td>2509.68</td>
</tr>
<tr>
<td>Minimum</td>
<td>1066.40</td>
<td>1234.49</td>
</tr>
<tr>
<td>CV*</td>
<td>0.1564</td>
<td>0.1384</td>
</tr>
</tbody>
</table>

* CV (Coefficient of Variation) = Standard Deviation / Mean
Figure 1. Price Movement of Cash and Futures: Corn

Figure 2. Price Movement of Cash and Futures: Soybeans
Table 2. Estimated Hedge Ratios with Minimum Variance and Minimum Semivariance

<table>
<thead>
<tr>
<th></th>
<th>Corn</th>
<th>Soybeans</th>
</tr>
</thead>
<tbody>
<tr>
<td>MVH</td>
<td>0.9506</td>
<td>0.9771</td>
</tr>
<tr>
<td>MSVH</td>
<td>0.4269</td>
<td>0.4521</td>
</tr>
</tbody>
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Table 3. Average Hedge Effectiveness for Alternative Hedging Strategies

<table>
<thead>
<tr>
<th>Hedging Strategies</th>
<th>Hedge Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Variance Reduction</td>
</tr>
<tr>
<td>MSVH</td>
<td>0.4678 (0.1763)</td>
</tr>
<tr>
<td>Corn</td>
<td>0.3931 (0.3623)</td>
</tr>
<tr>
<td>MVH</td>
<td>0.3434 (0.3897)</td>
</tr>
<tr>
<td>1-to-1 Naïve Hedge</td>
<td></td>
</tr>
<tr>
<td>MSVH</td>
<td>0.5561 (0.1121)</td>
</tr>
<tr>
<td>Soybeans</td>
<td>0.3413 (0.3718)</td>
</tr>
<tr>
<td>MVH</td>
<td>0.3113 (0.3901)</td>
</tr>
<tr>
<td>1-to-1 Naïve Hedge</td>
<td></td>
</tr>
</tbody>
</table>

Note: Numbers in parentheses are standard deviations of hedge effectiveness from each hedge period.
Figure 3. Hedge Effectiveness ($\text{HE}_{SV}$): Corn

Figure 4 Hedge Effectiveness ($\text{HE}_{SV}$): Soybeans