An Analysis of Alternative Hedging Strategies for Importing Corn: The Case of Taiwan

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Introduction

Taiwan is a surplus rice producer, but depends heavily on the imports of feed grains which are used as feed in the livestock industry. Traditionally, an importing country has to be concerned with only the management of commodity price risks. However, since the breakdown of the Bretton Woods fixed exchange regime in the early 1970s, exchange rates as well as interest rates became flexible. When a commodity is priced in an international currency such as the U. S. dollar, a variable exchange rate can change the value of the commodity in terms of the importing country's currency even though the price of the commodity is constant in terms of U.S. dollars. A flexible interest rate of major world currencies increases the risks for international traders who trade storable agricultural commodities by affecting the value of money borrowed or committed through international financial markets. The interest rate risk may also impact on the opportunity costs for importers in their own currencies in the course of importing and holding commodities. Finally, in addition to the increases in exchange rate and interest rate risks, the ocean freight rate has become more volatile.

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Therefore, as Leuthold (1986) illustrated, an importing country can no longer concern itself with just commodity price risk, rather it must concern itself with the combination of commodity price, exchange rate, interest rate and ocean freight rate risks.

As a result of government policies aimed to stabilize the price of feed grains and livestock products, the individual grain importer in Taiwan in fact does not face any risk while purchasing grains. However, drawbacks of the current policies resulted in a number of debates among the private and public sectors. In conjunction with luberalizing foreign exchange effective July 15, 1987, the government liberalized the grain purchasing system beginning in July, 1988. Taiwan importers, long under the protection of government policies, will be exposed to price risks in the international market under the liberalized purchasing environment. Hence, a study on risk management and marketing strategies for Taiwan importers under a liberalized importing system is necessary and timely.

The international uses of futures markets as a risk management tool has become an important research topic in recent years. The effectiveness of this tool for importers depends on the commodity traded, price relationship between the two trading countries and the economic and marketing environment in the importing country. This study focuses on using the futures market to manage commodity price risks for Taiwan importers of corn, one of the major feed grains imported by Taiwan and which comes principally from the United States. It serves as an example of how importers might use futures markets to manage their price risks. This study focuses on decisions faced by importers such as the timing of purchases and the level of commodity purchases in the futures market.

An Empirical Purchasing Model

Alternative importing strategies for private Taiwan corn importers are developed for the management of commodity price risks through the futures market. Other risks exists in foreign exchange rates, ocean freight rates and interest rates, but this study will concentrate on directly managing only corn price risks. At this time there is no U.S.-Taiwan exchange rate futures contract, and ocean freight rates began trading just in 1985. Also, futures markets on interest rates around the world are not very relevant to Taiwan importers. However, as we show later foreign exchange rate risk is indirectly managed in this study.

Because data on the demands or imports by individual industrial firms are not available, this study uses whole Taiwan imports to represent the typical import activity of the private importers. Also because the monthly consumption of corn is not available, the strategies examined in this study assume the quantity demanded each month is 1/12 annual demand. The annual import demand for each year is assumed known for each importer by the last quarter of the previous year.

Data are available for all the variables needed in this analysis from January 1975 through December 1975. Utilizing data from January 1975 to October 1980 and updating with new data each time a hedging decision is made, the monthly purchasing costs associated with each strategy developed in this study are simulated over 1981-1985. Therefore, the study is actually ex post but in an ex ante sense. Efficient strategies are selected based on the simulated observations by using mean-variance and Meyer's (1977) stochastic dominance with respect to a function criteria.

Hedging Strategies

Routine, selective and optimal hedging strategies are incorporated in this study. We assume that delivery from the futures market is not taken. The hedging decision is made in the first month of each quarter for each month in the following quarter. The hedging decision is made quarterly and cash grain is purchased monthly. If the expected monthly cash purchase has been hedged, an equivalent amount of hedge will be lifted when the cash is purchased. A definition of each hedging strategy is outlined below.

(1) Routine hedge

This is a full hedge strategy under which the expected cash purchase in each month of the following quarter is hedged in the first month of the current quarter.

(2) Selective hedge

Under this strategy an importer makes the decision to hedge or not during the first month of each quarter for each month in the following quarter. If in the first month of a quarter the futures price is forecasted to be lower than the forecasted futures for the month(s) during the following quarter, then the importer hedges for that (those) distant month(s) regardless of the difference between the two forecasted prices. That is, if futures prices are forecasted to trend upwards, importers hedge long. An importer does not hedge for certain month(s) in the following quarter if in the first month of a quarter the futures price for that month is forecasted to be higher than the forecasted futures prices in certain month(s) during the following quarter (i.e. a downtrend is forecasted). The Chicago futures price in a future month is forecasted by adding the Chicago cash price forecast and the Chicago basis forecast. The Chicago cash price is forecasted by using an ARIMA model. Chicago basis is forecasted by taking the average of the basis for the same delivery month for the most recent three years. Three observations are used in forecasting the Chicago basis.

(3) Optimal hedge

According to this strategy, an importer hedges a proportion of the expected cash purchase during the first month of each quarter for each month in the following quarter. The number of contracts placed is determined by the optimal hedging positions which we derived later.

Cash Strategy

For each hedging strategy, the cash product is purchased monthly for the expected import demand of the following month at the average import C&F (cost and freight) price of the month because it takes one month to ship corn from the U.S. to Taiwan. Cash-only purchasing is also studied as a separate strategy and used as a benchmark strategy for comparing with the hedging strategies.

Optimal Anticipatory Hedge

A corn importer is assumed to make hedging decisions during the first month of each quarter for each month in the following quarter. The first hedging decision is made in October 1980 for the cash purchases in January, February, and March of 1981. Recall that the importers are assumed to know their expected cash imports in each year by the last quarter of the previous year and that the expected monthly import demand is assumed to be 1/12 of the expected annual import demand. In this case we derive the optimal hedge under only price risk based on Peck's (1975) work. However, contrary to her estimation procedure, we estimate the variance and covariance matrix in the optimal hedge formula from historical data instead of the mean squared error of the forecasts.

In general, costs of futures trading include brokerage commission cost, interest on initial margin requirements and margin calls. Alexander et. al. (1986) showed that the opportunity cost of interest on margin deposits has limited effect on the futures position for corn producers in both Georgia and Illinois doing anticipatory hedging. Therefore, the opportunity cost (interest cost) on the margin deposit is not considered in this study. We also assume that the margin cost is zero, a common assumption used in the literature because on average occasional margin deficit is offset by occasional margin surplus (Peck, 1975; Chavas and Pope, 1982; Holt and Brandt, 1985). Therefore, the only cost of futures trading considered in the current study is the round-turn commission cost.

Assume the decision of hedging is made in period t, the hedge is lifted in period t+j and the contract purchased for a specific month, t+j, matures in month t+i where $i > j$. The realized purchasing cost under an optimal hedging strategy is:

$$C_{t+j} = P_{t+j}R_{t+j}Q_{c,t+j} + (F_t^{\,t+i} - F_{t+j}^{\,t+i})R_{t+j}Q_{h,t+j} + KR_t(Q_{h,t+j}/127) \qquad (1)$$

where: C_{t+j} = total actual cost of purchasing, NT$, j=3, 4, 5;

P_{t+j} = the cash price at which the physical product is purchased in month t+j, US$/metric ton (m.t.) j=3, 4, 5;

R_{t+j} = the U.S.-Taiwan exchange rate, NT$/US$, j=3, 4, 5;

$Q_{c,t+j}$ = known quantity of import in period t+j, m.t., j=3, 4, 5;

F_t^{t+i} = known futures price at which the futures contract is purchased, US$/m.t.;

F_{t+j}^{t+i} = the futures price when the hedge is lifted, US$/m.t., j=3, 4, 5;

$Q_{h,t+j}$ = quantity hedged for the purchase in month t+j, m.t., j=3, 4, 5;

K = known brokerage commission of purchasing and selling of a futures contract, which is approximately US$40;

R_t = known Taiwan-U.S. exchange rate at time of hedging, NT$/US$.

Since a metric ton of corn is approximately equal to 39.368 bushels of corn, the figure 127 in the cost equation is the number of metric tons in a corn futures contract, which is equal to 5,000 bushels. Since the basis is defined as the difference between futures and cash prices at a point in time, the futures price can be expressed as the sum of basis and cash price. Thus, the cost equation can also be shown as:

$$C_{t+j} = P_{t+j}R_{t+j}Q_{c,t+j} + (F_t^{t+i} - P_{t+j} - B_{t+j})R_{t+j}Q_{h,t+j} + KR_t(Q_{h,t+j}/127) \qquad (2)$$

where B_{t+j} = the basis when the hedge is lifted at period t+j, j=3, 4, 5, US$/m.t.

We assume that the expected disutility of importers is a function of expected cost and risk:

$$E(DU) = f(E(C), Var(C)). \qquad (3)$$

We further assume that the disutility function is exponential with monthly cost normally distributed. Thus, the objective of the importer can be expressed:

$$\text{Min. } E(DU) = E(C) + \lambda\ Var\ (C) \qquad (4)$$

where λ is the risk aversion coefficient and is greater than zero for risk averters.

At the time the hedging decision is made the quantity of import in period t+j, Q_{t+j}, the price at which the futures contract is bought, F_t^{t+i}, and the brokerage commission cost per contract, KR_t, are known. The optimal quantity of hedge, Q_h, monthly average of cash and futures prices and the U.S.-Taiwan exchange rate at the time cash corn is purchased are unknown. Given the cost in equation (2), the expected cost and the variance of the cost can be derived as follows:

$$E(C) = (Q_{c,t+j} - Q_{h,t+j})E(P_{t+j}R_{t+j}) + F_t^{t+i}Q_{h,t+j}E(R_{t+j}) - Q_{h,t+j}E(B_{t+j}R_{t+j}) + KR_t(Q_{h,t+j}/127 \qquad (5)$$

$$
\begin{aligned}
Var(C) = E[C-E(C)]^2 \\
&= (Q_{c,t+j}-Q_{h,t+j})^2 \sigma_{PR}^2 + (F_t^{t+i} Q_{h,t+j})^2 \sigma_R^2 \\
&\quad + Q_{h,t+j}^2 \sigma_{BR}^2 \\
&\quad + 2(Q_{c,t+j}-Q_{h,t+j}) F_t^{t+i} Q_{h,t+j} \sigma_{PR,R} \\
&\quad - 2(Q_{c,t+j}-Q_{h,t+j}) Q_{h,t+j} \sigma_{PR,BR} \\
&\quad - 2F_t^{t+i} Q_{h,t+j}^2 \sigma_{R,BR} \qquad (6)
\end{aligned}
$$

where: $E(P_{t+j}R_{t+j})$ = the expected C&F cash price of corn, NT$/m.t.;

$E(R_{t+j})$ = the expected U.S.-Taiwan exchange rate, NT$/US$;

$E(B_{t+j}R_{t+j})$ = the expected Taiwan basis, NT$/m.t.;

σ_{PR}^2 = the variance of C&F cash price in NT$;

σ_R^2 = the variance of U.S.-Taiwan exchange rate;

σ_{BR}^2 = the variance of Taiwan basis in NT$;

$\sigma_{PR,R}$ = the covariance between C&F cash price of corn in NT$ and U.S.-Taiwan exchange rate;

$\sigma_{PR,BR}$ = the covariance between C&F cash price of corn in NT$ and Taiwan basis in NT$;

$\sigma_{R,BR}$ = the covariance between the U.S.-Taiwan exchange rate and the Taiwan basis in NT$.

Substituting the expected cost and variance of cost equations (5) and (6), respectively, into the objective function in equation (4), the optimal hedge is then obtained by setting the partial derivative of the objective function with respect to the quantity to hedge equal to zero. The resulting optimal anticipatory hedge is:

$$
Q_{h,t+j}^* = \frac{X}{-2\lambda Z} + \frac{Y}{Z} Q_{c,t+j} \qquad (7)
$$

where $X = F_t{}^{t+i}E(R_{t+j}) - E(P_{t+j}R_{t+j}) - E(B_{t+j}R_{t+j}) + (KR_t/127)$

$$Y = \sigma_{PR}{}^2 - F_t{}^{t+i}\sigma_{PR,R} + \sigma_{PR,BR}$$

$$Z = \sigma_{PR}{}^2 + (F_t{}^{t+i})^2\sigma_R{}^2 + \sigma_{BR}{}^2 - 2F_t{}^{t+i}\sigma_{PR,R} + 2\sigma_{PR,BR} - 2F_t{}^{t+i}\sigma_{R,BR}.$$

Only when the second order condition is greater than zero is the minimum of disutility assured. The second partial derivative of disutility with respect to the quantity hedged is $2\lambda[\sigma_{PR}{}^2 + (F_t{}^{t+i})^2\sigma_R{}^2 + 2\sigma_{BR}{}^2 - 2F_t{}^{t+i}\sigma_{PR,R} + 2\sigma_{PR,BR} - 2F_t{}^{t+i}\sigma_{R,BR}]$. Since the sign of the second order condition is not obvious, the second order condition is checked empirically to see if the optimal hedge results in the minimum disutility.

Peck's analysis of the optimal hedge of an egg producer assumed risk aversion ranged from 0.001 to 0.1. Rolfo (1980) in the analysis of optimal hedging for cocoa producers in four developing countries assumed the risk aversion between 0.00001 to infinity. There seems to be no study on optimal anticipatory hedging from a buyer's view point which parameterized the risk aversion coefficient. This study only considers the marketing plan for the risk averter and risk aversion is parameterized from 10^{-5} to 10^5.

In the optimal hedge equation, the expected cash price and foreign exchange rate are forecasted by a univariate Box and Jenkins (1976) model. The Taiwan basis is forecasted by taking the average of the basis for the same delivery month for the most recent three years. The variance and covariance of the cash price, foreign exchange rate, and basis are calculated using historical data from January 1975 through September 1980 and updating quarterly with new data each time the optimal hedge is estimated. The use of historical variance and covariance as the forecast is based on an assumption that the variance and covariance are stable.

The optimal number of contracts to purchase is obtained by dividing Q_h* by 127 which is the number of metric tons per contract. The estimate of optimal number of futures contracts to purchase is continuous, but futures contracts are indivisible and discrete. The use of rounded-off continuous solutions as an approximation of discrete solutions may be suboptimal. The potential problem has been noticed by Heifner (1966), Baum, Carlson and Jucker (1978), Robison and Barry (1980), Rausser (1980) and Anderson and Danthine (1981). However, after solving the problem by using a discrete optimization technique, Peterson (1982) found that the discrete solutions were nearly identical to the corresponding rounder-off continuous solutions, and suggested that for problems of this type, the use of a discrete optimization technique is not critical. Therefore, a rounded-off approach will be used in this study.

The optimal number of futures contracts to buy will be estimated for March, July, September, and December contracts to determine the amount to hedge for months within the calendar quarters 1, 2, 3, and 4, respectively.

ARIMA Forecasting Procedure for Prices

The univariate ARIMA (Autoregressive Integrated Moving Average) models are estimated by following the identification, estimation and diagnostic checking procedures. Standard Box and Jenkins (1976) time series forecasts are then made for determining the timing of hedging for selective hedging strategies. For this purpose, the Chicago cash price of corn is forecasted for one and four through six months ahead.

In the estimation of the optimal hedge the C&F cash price of corn in NT$, and U.S.-Taiwan exchange rate are forecasted for four, five and six months ahead using a time series model. All the ARIMA models are updated quarterly.

Data Sources

Monthly averaged futures price of corn quoted at the Chicago Board of Trade and monthly averaged Chicago cash prices used in this study are compiled from the Wall Street Journal. The import C&F (cost and freight) prices of corn from the U.S. in US$ are obtained from Monthly Journal of Grains, Feeds, and Livestock published by Taiwan Grains and Feeds Development Foundation. The monthly C&F price is the average price of corn arrived in Taiwan weighted by quantity. The monthly averaged U.S.-Taiwan exchange rates are available from Financial Statistics Monthly, Taiwan District, The Republic of China published by Economic Research Department of the Central Bank of China. The exchange rates are used to transform the prices in U.S. dollars such as the C&F import price of corn, Chicago cash and futures price of corn, and the brokerage commission into prices in New Taiwan dollars. For all of the variables in the current study, monthly data are available from January, 1975 through December, 1985.

Computing Monthly Cost

The monthly cost associated with each hedging/cash and cash-only strategy is estimated as follows.

If the cash purchase for the month is hedged, the monthly cost includes cash purchasing cost, commission cost of hedging and the loss from hedging. Monthly cash purchasing cost is the product of the monthly average cash price in NT$ and expected import demand of the following month. Commission cost is the product of US$40, U.S.-Taiwan exchange rate, and the number of contracts hedged for the month. The loss from hedging is the product of the loss from hedging per unit in NT$ and the quantity hedged. The loss from hedging per unit in US$ is calculated by the difference of average futures prices at which the hedge is lifted and placed. This loss is then converted to NT$ at the time the hedge is lifted. If the cash purchase for the month is not hedge, the monthly cost involves only the cash purchasing cost. Monthly costs associated with each hedging and cash strategy are simulated from January, 1981 through December, 1985.

Strategy Selection

An evaluation of each hedging strategy will be based on the monthly costs and risks simulated. Using the mean-variance efficiency criterion as shown in figure 1, hedging strategies are compared with the cash-only strategy. The cash-only strategy is a benchmark.

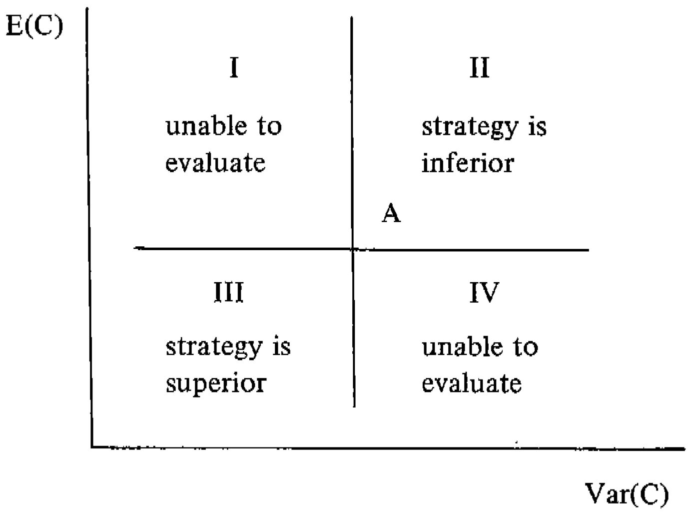

Figure 1 Mean-Variance Comparison of Hedging Strategies with the Cash-only Strategy

If a strategy results in lower mean and variance of the cost relative to the benchmark strategy (point A in figure 1), then the result would fall in quadrant III and the strategy would be considered as superior. If the strategy produces a higher mean and variance of the cost than the benchmark strategy, the result will fall in quadrant II and the strategy is considered inferior. Should the strategy fall in either quadrant I or IV, it is not possible to determine if a strategy is superior or inferior to the benchmark strategy without knowing the decision maker's response to risk. Therefore, a more discriminatory efficiency criteria, stochastic dominance with respect to a function, will also be used to rank the strategies.

In the use of stochastic dominance with respect to a function criterion the interval of absolute risk aversion is selected to cover the range reported in the literature (Kramer and Pope, 1981; Tauer, 1985). The lower and upper bounds of the absolute risk aversion coefficient (r(y) suggested by the literature are presented in table 1. A zero for r(y) indicates risk neutral. Since only risk averters are considered in this study, the negative risk aversion is not shown. The larger the actual value of the absolute risk aversion, the more risk averse is the importer. Empirical evidence shows that many individuals would fall within utility group 1 (King and Robison, 1984). This is further supported by Kramer and Pope (1981).

Table 1 Intervals of Absolute Risk Aversion Coefficients.

	r(y)	
Utility Group	Lower Bound	Upper Bound
1	0.00000	0.00125
2	0.00125	0.00250
3	0.00250	0.00500
4	0.00500	0.00750
5	0.00750	0.01000
6	0.01000	0.01500
7	0.01500	0.02000
8	0.02000	0.03000

Results

Cash-only Strategy

The monthly purchasing costs associated with the cash-only strategy are calculated by multiplying the unit C&F price (US$/metric ton) by the U.S.-Taiwan exchange rate (NT$/US$), and the monthly purchases (metric ton). The monthly import demands are 217, 617, 212, 356, 288, 247, 246, 662, 251, 402, and 255, 896 metric tons for 1981, 1982, 1983, 1984, 1985, and 1986, respectively.

The mean and standard deviation of the monthly cost under cash-only strategy is 1,452,176 and 175,223 thousand new Taiwan dollars, respectively. Standard deviation will be used instead of variance throughout this study for it gives a clearer idea on how the data deviate from the mean.

Routine Hedge Strategy

Under the routine hedge strategy the number of contracts purchased by the importers in each month was obtained by taking the monthly import demand in metric tons and dividing by 127. For a long hedge, loss occurs when the futures price goes down and gain occurs when the futures price goes up. The loss from hedging in US$ is calculated by multiplying the number of contracts held for a month by the amount per contract that the price decreased during the month times 5,000. The loss in US$ is then converted into NT$ using the exchange rate.

During the sample period only in 18 out of 60 months did importers gain from routine hedging. The total net loss during the five-year period comes to 2,283 million new Taiwan dollars. The reason for the big loss from the routine hedge strategy is that the futures price trended downward most of the time during the sample period.

In order to calculate the monthly purchasing cost associated with the routine hedge strategy the monthly cost of futures tarding has to be calculated. The monthly costs of futures trading are US$ 40 times the number of contracts purchased monthly and then converted by the exchange rate (US$/NT$).

The total monthly purchasing costs are calculated by summing the cash purchasing cost, loss from hedging and the round-turn commission cost of futures trading. The mean and standard deviation of the cost under the routine hedge strategy is 1,493,247 and 166,488 thousand new Taiwan dollars, respectively. It can be seen by comparing these results with those from the cash-only strategy that the routine hedge strategy resulted in a higher average cost and lower standard deviation than the cash-only strategy.

Selective Hedge Strategy

Under the selective hedge strategy, the hedging decision is made in the first month of each quarter for each month in the following quarter based on the forecasts of Chicago futures prices for one, four, five and six months ahead. The forecasting procedure was described earlier. The forecast of Chicago futures price is composed of the Chicago cash price forecast plus the Chicago basis forecast.

The first hedging decision is made in October 1980 for the first three months in 1981 based on the data from January 1975 through September 1980. The number of observations used for this forecast is 69. The second hedging decision is made in January 1981 based on the data from January 1975 through December 1980. The number of observations used here is 72. The same procedure is followed until the last hedging decision made in July 1985 for the last quarter in 1985.

The models are ARIMA (1,1,0) for each period. In this study, the goodness of fit of the model is mainly judged by the Q test on the residuals. The hypothesis that the residuals are white noise is rejected when values of the Q statistics are large relative to the value from a Chi-square distribution table. Q is approximately Chi-squared distributed with k-p-q degrees of freedom where k refers to the number of autocorrelations considered; p and q stand for the order of AR and MA, respectively. The Chi-square test is conducted for k equals 12 and 24. The critical value of the Chi-square distribution with 11 and 23 degrees of freedom is 19.7 and 35.2, respectively, at the 0.05 significance level. Since all the Q statistics are below these critical values, the models are considered adequate. Other techniques suggested in the literature for diagnostic checking of the model adequacy such as overfitting the model were also done and they confirmed the adequacy of the above models.

The Chicago cash prices are therefore forecasted based on the ARIMA model built. The root mean square error (RMSE) of the Chicago cash price forecasts is 37.228 cents per bushel, and the root mean square percentage error (RMSPE) is 14%.

The RMSE of Chicago basis forecasts is 13.745 cents per bushel and the RMSPE is 303%. The forecasts obtained by averaging the basis for each specific delivery month for the past three years are not good.

The Chicago futures prices are forecasted by summing the respective forecasted Chicago cash price and basis. The RMSE of the Chicago futures price forecast is 38.609 cents per bushel. Despite the high RMSPE for the Chicago basis forecasts, the RMSPE of the Chicago futures price forecasts is about the same as the RMSPE of the Chicago cash price forecast at 14%. This result is because the Chicago basis is small relative to the Chicago futures price.

The hedging signal for the importer in each month is summarized in table 2. In table 2 "NH" indicates "not to hedge" and "H" indicates "to hedge". The symbol "*" indicates the signals obtained for the selective hedging strategy are correct. In only 8 out of 60 months, which is 30%, the futures price trended upward and the importer should have been hedged during the sample period. The importer should not have hedged at all in 1981 and should have hedged for only one, three and two months in 1982, 1984, and 1985, respectively. Due to a serious drought in 1983 futures prices trended upward,meaning importers should have hedged cash purchases in every month of 1983. Table 2 shows that in 38 out of 60 months, which is 63%, the selective hedge strategy gives correct signals.

Table 2 Months Hedged under Selective Hedge Strategy

Year Month	1981	1982	1983	1984	1985
January	NH*	NH*	NH	NH*	NH*
February	NH*	NH*	NH	NH*	NH*
March	NH*	NH*	NH	NH*	NH*
April	NH*	NH	NH	NH	NH
May	NH*	NH*	NH	NH	NH*
June	NH*	NH*	NH	NH	NH*
July	NH*	NH*	NH	NH*	NH*
August	NH*	NH*	NH	NH*	NH*
September	NH*	NH*	NH	NH*	H
October	NH*	NH*	H*	H	H
November	NH*	H	H*	H	H
December	NH*	NH*	NH	H	H*

NH = Not to hedge
H = Hedge
* = Correct Signal

In calculating the purchasing costs associated with the selective hedge strategy, those months in which the cash purchases are not hedged the monthly costs are the same as those under the cash-only strategy. For those months in which the cash purchases are hedged the monthly costs are the same as those under the routine hedge strategy.

The mean and standard deviation of the monthly costs under the selective hedge strategy are 1,454,962 and 164,017 thousand new Taiwan dollars. Comparing the results of monthly costs associated with cash, routine, and selective hedge strategies, it can be seen that the cash strategy resulted in lowest average cost and highest standard deviation. The selective strategy gives a second highest mean and standard deviation.

Optimal Hedge Strategy

In order to estimate the optimal anticipatory hedge for Taiwan importers as presented in equation (7), the C&F cash price of corn in Taiwan, Taiwan bases, and the exchange rates between U.S. and Taiwan have to be forecasted. The monthly Taiwan bases are forecasted by taking the average of the monthly Taiwan bases for an appropriate delivery month for the three most recent years. The C&F price of corn in Taiwan and the exchange rates between U.S. and Taiwan are forecasted by using ARIMA models.

The first differenced C&F price up to September 1980 is a white noise series, so in October of 1980 the forecasts of C&F price for January, February, and March of 1981 are just the C&F price in September 1980. Between January 1981 and December 1982 the models are ARIMA (7,1,0), and between January 1983 and December 1985 the models are ARIMA (10,1,0). The RMSE of the C&F price forecasts for four, five and six months ahead is NT$ 749.0 and the RMSPE is 13%.

The Q statistics of the first differenced U.S.-Taiwan exchange rate are less than 10 for k equals 12 and 24. The critical values of the Chi-square distribution with 12 and 24 degrees of freedom are 19.7 and 35.2, respectively, given a significance level of 0.05. Therefore, the first differenced U.S.-Taiwan dollar exchange rate is a white noise series. Since the exchange rate changes infrequently during the sample period, the differenced exchange rates are zeros except when there are changes set by the central bank. The forecasts for exchange rates are the last observation used in the estimation of the model. For example, in the beginning of October 1980 the forecasts of exchange rate for January, February, and March of 1981 the exchange rate in September 1980. The RMSE of the exchange rate forecasts is NT$ 0.73 per US$, and the RMSPE is 2%.

The RMSE of the Taiwan basis forecasts is NT$ 768.94 and the RMSPE is 83%. Both the Chicago basis forecasts and the Taiwan basis forecasts have extremely high RMSE and RMSPE.

The forecasts of Taiwan C&F cash price (NT$/m.t.), Taiwan-US exchange rate (NT$/US$), the Taiwan bases (NT$/m.t.) are used to estimate the optimal hedge. The forecasts of variance and coveriance of price, basis and exchange rate calculated using the historical data are updated quarterly. With these forecasts and calculated variance and covariance the optimal number of contracts to purchase under only price risk can then be estimated by using equation (7). The optimal hedges for each month for importers with risk aversion coefficients between 10^5 and 10^{-4} are the same. This is because the futures forecast error is in the numerator and the risk aversion, λ, is in the denominator of the first term in equation (7). When the futures forecast errors are small and λ is large the first term disappears. In this case as long as λ is greater than 10^{-4} the first term is essentially zero.

The second derivatives of the disutility with respect to the quantity hedged are all greater than zero for each optimal hedge obtained. Therefore, the minimization of the disutility is assured by the optimal hedge.

There is a difference at most of two contracts in a month for importers with different risk aversion. Increases in risk aversion may either increase or decrease the optimal hedge. Whether an increase in the risk aversion, λ, increases or decreases the optimal hedge is dependent on the signs of X and Z in equation (7). In equation (7) X represents the futures forecast error and Z is a linear combination of variance and covariance of price, basis, and exchange rate. When the futures market overestimates (underestimates) the cash price in the future, X has a positive (negative) sign. When the product of X and Z in equation (7) is positive (negative), the larger the λ the larger (smaller) is the optimal hedge with other things being held constant.

The optimal hedge ratios for importers under only price risk are calculated by dividing the optimal number of contracts by the number of contracts purchased under the routine hedge strategy. The optimal hedge ratios are the same for λ ranges from 10^5 to 10^{-5} because the number of contracts purchased for each group are very close. The ratios are shown in table 3.

Table 3 Optimal Hedge Ratios under Only Price Risk for λ Ranges from 10^5 to 10^{-5}

Year Month	1981	1982	1983	1984	1985
January	0.66	0.92	0.88	0.81	0.91
February	0.66	0.92	0.88	0.81	0.91
March	0.66	0.92	0.88	0.81	0.91
April	0.75	1.05	1.00	0.97	1.04
May	0.75	1.05	1.00	0.97	1.04
June	0.75	1.05	1.00	0.97	1.04
July	0.82	1.02	0.92	0.97	1.03
August	0.82	1.02	0.92	0.97	1.03
September	0.82	1.02	0.92	0.97	1.03
October	0.85	0.96	0.83	0.89	0.89
November	0.85	0.96	0.83	0.89	0.89
December	0.85	0.96	0.83	0.89	0.89

The mean of the optimal hedge ratios is 0.91 and the standard deviation is 0.10. During the sample period the importers would have hedged less than but very close to 100%. In 12 out of 60 months, or 20%, the importers hedge more under the optimal hedge strategy than the routine hedge strategy.

For importers using the optimal hedge strategy the total cost of imports is composed of the monthly cash purchasing cost, loss from the futures trading, and the round-turn commission costs. The monthly cash purchasing cost is the same as in the cash-only strategy. The loss from the futures trading is calculated by first determining the loss per bushel in US$, and then multiplying the loss per bushel by the total number of bushels hedged. The total bushels hedged is equal to the number of contracts hedged times 5,000 bushels. This loss is then converted into NT$ at the current exchange rate. Since the optimal hedges are the same for importers with risk aversion greater than or equal to 10^{-4}, the monthly costs are the same for these importers.

For importers with λ equal to 10^{-5}, the number of contracts purchased is slightly different. The total loss from futures trading, the round-turn commission cost and the total cost of purchasing are therefore different.

The mean and standard deviation of the total cost are 1,488,772 and 159,334 thousand new Taiwan dollars, respectively, for importers with λ between 10^5 and 10^{-4}. They are 1,488,788 and 159,339 new Taiwan dollars, respectively, for importers with λ equal 10^{-5}. These differences are so slight that we will consider the first set of results as representative of the optimal hedge strategy. The optimal hedge strategy resulted in the second highest monthly average cost and lowest standard deviation among the four strategies discussed in this study.

The futures prices for each relevant contract trended downwards most of the time during the sample period except in 1983 in which there was a serious drought. Therefore, more losses are incurred to the importers than gains. The loss from hedging under the optimal hedge strategy and the routine hedge strategy can be compared. Out of 42 months in which losses are incurred to the importers, the optimal hedge strategy resulted in smaller losses than routine hedge strategy in 32 cases. Out of 18 months in which importers gained from hedging, the optimal hedge strategy generally resulted in smaller gains than routine hedge strategy in 13 cases. The importers have more moderate losses or gains under the optimal hedge strategy than under the routine hedge strategy because most of the time the optimal hedge ratios are less than 1. Therefore, its standard deviation is also smaller under the optimal hedge strategy than under the routine hedge strategy.

Evaluation of Strategies

Each strategy is evaluated based on the sixty monthly costs simulated. As noted earlier two criteria are used to rank these strategies, the mean-variance criterion and stochastic dominance with respect to a function.

(1) Mean-Variance Criterion

Under this criterion, the strategies are ranked based on the mean and variance (or standard deviation) of the simulated monthly costs in table 4.

Table 4 Mean and Standard Deviation of Monthly Costs Associated with Each Strategy for Importers with λ Between 10^5 and 10^{-4} (NT$1,000)

Strategy	Mean	Standard Deviation
Cash	1,452,176	175,223
Routine	1,493,247	166,488
Selective	1,454,962	164,017
Optimal	1,488,722	159,334

Relationships between the strategies are plotted in figure 2. Each strategy is represented by its first letter, for instance, C stands for cash strategy, R for routine, S for selective and 0 for optimal.

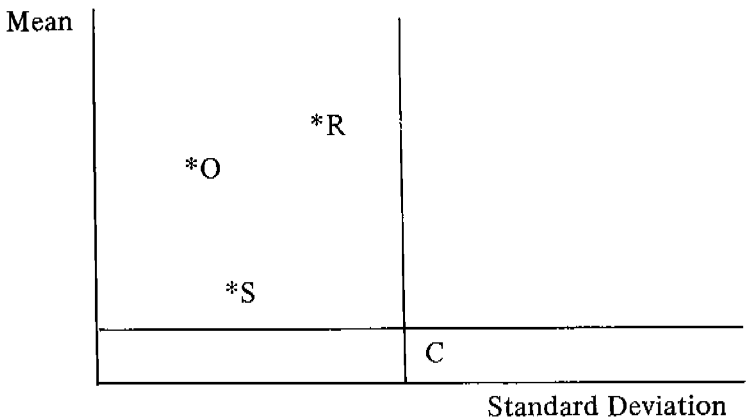

Figure 2 The Mean and Standard Deviation of the Strategies

From figure 2 it can be seen that among the strategies, the routine hedge strategy is dominated by optimal hedge as well as selective hedge strategies. The routine, selective, and optimal hedge strategies all fall into the indecisive quadrant relative to cash strategy. That is, no strategy has lower mean and standard deviation than cash, therefore no dominance can be said relative to the cash strategy. O, S, and C form an efficient frontier. Though the cash strategy gives the lowest cost, it results in the highest standard deviation among this set. Presumably, a more risk averse person would prefer O while a less risk averse person would prefer C.

It is impossible to completely rank these strategies using mean-variance criterion. Therefore, a more discriminating criterion, the stochastic dominance with respect to a function criterion, is used.

(2) Stochastic Dominance with Respect to A Function Criterion

The strategies are ranked based on the stochastic dominance criterion for importers with various λ as well as various ranges of absolute risk aversions. The rank of strategies turns out to be the same across all importers with various values of λ which ranges from 10^5 to 10^{-5}. The ranges of absolute risk aversion used in this study have been presented in table 1. Only positive absolute risk aversions for risk averters are considered in this study. The larger the absolute risk aversion, the more risk averse person it represents. Eight utility groups (utility group 1, 2, . . . , 8) are analyzed. The rank for various utility groups with various ranges of absolute risk aversion is presented in table 5. In table 5 "1" indicates the strategy in the first column of the table dominates the strategy in the second column of the table; "O" indicates the importers are indifferent between the strategy in the first and second column of the table; "–1" indicates the strategy in the first column is dominated by the strategy in the second column for a specific utility group. The higher the utility group number, the more risk averse the importers are. For instance, the importers in group 8 are more risk averse than the importers in group 1 through 7.

Table 5 Results from the Stochastic Dominance Comparision of Each Strategies

Strategy vs. Strategy		Utility Group							
		1	2	3	4	5	6	7	8
Cash	Routine	1	1	1	1	1	1	1	1
Cash	Selective	1	1	0	–1	–1	–1	–1	–1
Cash	Optimal	1	1	1	1	1	1	0	–1
Routine	Selective	–1	–1	–1	–1	–1	–1	–1	–1
Routine	Optimal	–1	–1	–1	–1	–1	–1	–1	–1
Selective	Optimal	1	1	1	1	1	1	1	1

It can be seen from table 5 that while comparing two strategies "0" indicates a transition from "1" to "−1". A summary of the ranking of the strategies derived from the result in table 5 for each utility group is presented in table 6.

Table 6 A Summary of the Ranking of Each Strategy

Utility Group	Sequence of Dominant Strategy
1	C > S > O > R
2	C > S > O > R
3	C = S > O > R
4	S > C > O > R
5	S > C > O > R
6	S > C > O > R
7	S > C = O > R
8	S > O > C > R

Each choice is superior or indifferent to the choice to its right. The results shown in table 6 are consistent with those results based on the mean-variance (or standard deviation) criterion. However, the stochastic dominance criterion is much more discriminating than the mean-variance criterion.

Table 6 shows that the best strategy for utility groups 1 through 3 is the cash strategy. The best strategy for utility groups 4 through 8 is the selective strategy. Importers within these groups prefer hedging in the futures market when the futures price in the U.S. is forecasted to be trending upwards. Therefore, as the importers become more risk averse they would rather choose the strategy which results in a lower standard deviation at the expense of higher cost.

Conclusion

The study indicates that during 1981 through 1985 a

Taiwan importer who is slightly risk averse and buys corn monthly prefers not to use the futures market for hedging if satisfactory forecasts do not exist. However, more risk averse importers prefer the selective hedge strategy.

For importers studied here optimal and routine hedging strategies were the worst two strategies. The unsatisfactory optimal hedging strategies perhaps result from a combination of the price trend during the sample period and a poor forecast. The Chicago futures price trended downwards during the period when the importers were holding long contract positions, except during 1983 when there was a serious drought and prices moved upward. Importers long in the futures market incurred losses from futures trading most of the time during the sample period. Therefore, in years of large crops the importers would not likely benefit from the futures trading but would likely benefit when crops are smaller than expected. If this study had been done for a short hedger of corn in Taiwan, the implications would be totally different. A short hedger in Taiwan during the sample period would have found hedging very beneficial. The results also show the forecasting model used in this study is not highly accurate. Better forecasts would have seen downtrending prices. The unsatisfactory routine hedging strategy results come solely from the downtrending futures price during the sample period.

The comparison of strategies is based on the mean and standard deviation of monthly costs. Such benefits of hedging as providing importers forward prices, flexibility in pricing, storage of physical commodity, and information of price and stocks are either not quantifiable or comparable. Therefore, the selection of strategies for each importer has to be made more carefully than just comparing the mean and standard deviation associated with each strategy. Nevertheless, the futures market can be used effectively for risk management by importers.

There are some shortcomings to this study. The forecasts of the price series are made by either taking a three-year moving average or using univariate time series analysis. Other forecasting techniques such as using multivariate time series analysis, an econometric model, or a vector autoregressive model are not considered. An investigation of more sophisticated methods to forecast prices is needed, especially for the purpose of determining the timing of hedges for the selective hedging strategy.

Due to the insufficiency of data on ocean freight rates as well as its futures price, the effectiveness of using the futures market to manage the risk of ocean freight rates is not studied. As more data on ocean freight rates becomes available, the use of ocean freight rate futures should be evaluated. The methodology used in this study can be applied to the importing of other bulky grains such as soybeans and wheat for Taiwan.

In this study, only import demands as opposed to the total demands in Taiwan are considered because of the lack of data. This study would be more complete if it accounted for the total demand.

Forward pricing of the US-Taiwan exchange can be useful in managing the exchange rate risk. Not all of the possible strategies which might be applied to the futures market are explored. Alternative hedging strategies such as holding the futures positions for different time spans may bring different results and should be examined in future research. Also, expanding this study to imports of several kinds of grain simultaneously for their similarities in usage as well as storage could also be an interesting topic. This expansion could include studying commodity price, exchange rate, interest rate and ocean freight rates simultaneously.

Nevertheless, this study demonstrates a procedure and methodology for hedging corn by importers in Taiwan under the proposed liberalized grain purchasing system. Since importers will be assuming their own price risks, it is important that they become aware of and follow models as suggested here. Although the optimal hedging results do not dominate because of downtrending prices and poor forecasts, this technique in the long run may become very important.

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進口玉米替代海京策略之分析
—台灣之實證

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摘 要

自一九七〇年代初，台灣大宗穀物進口商即受政府保護，在幾乎不受任何採購的風險下進口穀物，近年來，大宗穀物進口政策引發許多爭議，在經貿自由化的目標下，政府有意於一九八八年七月一日起開放玉米、黃豆之自由進口，如此一來進口商必須開始承受採買風險，此文的目的即在於幫助玉米進口商在自由採買的環境下做風險的管理。此研究設計、分析以及建議進口商利用美國期貨市場進口玉米之策略，應用期貨交易和證券理論並使用時間數列預測和最適期貨交易等模型模擬各策略之進口成本，再依此模擬得之進口成本將各策略加以比較。由一九七五年至一九八五年之月資料分析，結果顯示現貨採買適於略爲不好風險之進口商，而對於惡風險之進口商，選擇性的海京爲最佳的策略。