SIMPLE RISK MEASURES WHEN HEDGING COMMODITIES USING FOREIGN MARKETS: A NOTE

FRANK S. NOVAK
JAMES R. UNTERSCHULTZ

INTRODUCTION

To manage price risk, investors need to evaluate and measure the different risks they face. For commodity producers, these risk measures must represent the uncertainty or risk actually being confronted over the production period. After the production decision has been made, the only relevant price variability is that which makes the actual sale price differ from the forecast price [Peck (1975)]. The crucial variance is that which surrounds the accuracy of the producer's forecast, the mean squared error (MSE) of the forecasts.[1]

The authors wish to thank S. Koontz and R. Tronstad for their comments on an earlier draft of this article and G. Mumey for this ideas on measuring exchange rate risk.

[1]Holt, Brandt, and Hurt (1985) and Brandt (1985) used MSE to show that it is possible to improve returns and reduce short-run risk in the hog industry. Kenyon and Clay (1987) used the idea of perfect forecasts to measure the benefits of hedging during different parts of the hog cycle. Their results indicate that hog producers can increase returns and decrease the variance of returns using this approach.

■ *Frank S. Novak is an Associate Professor in the Department of Rural Economy at the University of Alberta.*

■ *James R. Unterschultz is an Assistant Professor in the Department of Rural Economy at the University of Alberta.*

The Journal of Futures Markets, Vol. 16, No. 2, 211–217 (1996)

CCC 0270-7314/96/020211-07

This article presents a simplified method for measuring the short run total price risk reduction possible when using commodity futures markets in foreign countries. Short run price risk is decomposed into futures price risk, basis risk, and currency risk by using "perfect" forecasts, similar in spirit to those of Kenyon and Clay (1987). The decomposition is generally applicable to all cases where short run risk is measured using MSE and price forecasts are derived from the futures markets. The information derived from this type of decomposition may be useful in measuring the relative contribution of different risk sources and developing specific management strategies.

An empirical application of this methodology is demonstrated by measuring the various risks facing a Canadian cattle feeder using U.S.-based futures markets for hedging. The Canadian feeder is considered a foreign hedger and must deal with the added risk of adverse currency changes during the period of any hedge [Benninga, Eldor, and Zilcha (1985); Thompson and Bond (1987); Braga (1990)]. To manage this price risk these investors need to evaluate and measure the commodity and currency price risk involved when hedging in a foreign market. The following sections describe the price risk decomposition and a cattle pricing simulation model. Using the MSE risk measure, it is found: that the futures market can be used for risk management in Canada, that basis risk, while significant, does not preclude hedging to reduce price risk; and that exchange rate risk is small.

MEASURING SHORT RUN RISK

The MSE risk measure of net price (NP) is measured as the squared deviation of the realized net price from the forecast net price as:

$$MSE = \frac{\sum_{t=-i+1}^{T-i} (NP_{t+i} - \tilde{NP}_{t+i})^2}{T - 1} \qquad (1)$$

where T is the total number of periods, i is the forecast length, and $\widetilde{NP}_{t+1}$ is the forecasted net price for period $t + 1$. Thus, an initial step in measuring MSE risk requires a net cash price forecast. For short-term price forecasts (say from one to five months), the relevant futures price adjusted by a spot currency forecast is combined with a local basis forecast to provide a forecast of the local cash price.[2] Cash forecasts

[2]Basis is defined as the difference between the domestic cash price and the relevant foreign futures price adjusted for currency.

based on the foreign futures market, the forecast spot exchange rate, and a local basis forecast have some justification. The futures market must be strongly related to the local commodity market or hedging using this market is not justified. The spot exchange rate forecast can be the current spot exchange rate in many cases [see Boothe and Longworth (1986); Wolff (1988); Chrystal and Thornton (1988)]. Basis forecasts can be developed using simple averages, rolling averages, or even using Box–Jenkins ARIMA modeling. This gives a cash price forecast of

$$\tilde{CP}_{t+i} = FP_{j,t}X_t + \tilde{B}_{t+i} \tag{2}$$

where "~" represents forecasts, $\tilde{CP}$ is the local cash price forecast, $\tilde{B}$ is the nearby basis forecast, $FP_{j,t}$ is the current commodity futures price for contract month j that is used to forecast the expected futures price at time $t + i$, and X_t is the currency spot rate used to forecast the expected spot exchange rate at time $t + i$. If commodity hedges and currency hedges are added to the investment, then the realized net price with no hedging, commodity hedging only, and combined commodity–currency hedging, respectively, are:

$$NP_{t+i} = CP_{t+i} \tag{3}$$

$$NP_{t+i} = CP_{t+i} + \left(FP_{j,t} - FP_{j,t+i}\right)X_{t+i} \tag{4}$$

$$NP_{t+i} = CP_{t+i} + \left(FP_{j,t} - FP_{j,t+i}\right)X_{t+i} + FP_{j,t}\left(FX_{j,t} - FX_{j,t+i}\right) \tag{5}$$

and the forecast net price with a commodity and currency hedge is:

$$\tilde{NP}_{t+i} = \tilde{CP}_{t+i} + \left(FP_{j,t} - \tilde{FP}_{j,t+i}\right)\tilde{X}_{t+i} + FP_{j,t}\left(FX_{j,t} - \tilde{FX}_{j,t+i}\right) \tag{6}$$

where NP_{t+i} is the net price, X_{t+i} is the spot exchange rate converting foreign dollars to domestic dollars, and FX is the futures exchange rate converting foreign dollars to domestic dollars. Under the assumption of unbiased futures prices used in this article, the expected forecast net price with a commodity and currency hedge always reduces to $\tilde{CP}$.

Making use of the equations for net price under the different hedging strategies, one can now return to the MSE risk measure in eq. 1. The total price risk can now be decomposed into three components: futures price risk, commodity basis risk, and total exchange rate risk, as follows.

Expanding the MSE to show the different sources of risk when there is no currency or commodity hedging gives:

$$MSE = \frac{\sum_{t=-i+1}^{T-i} [(FP_{j,t+i}X_{t+i} - FP_{j,t}X_t) + (B_{t+i} - \tilde{B}_{t+i})]^2}{T - 1} \quad (7)$$

The total price risk is composed of futures price risk, the change in $FP_{j,t}$ to $FP_{j,t+i}$, exchange rate risk, the change in X_t to X_{t+i}, and commodity basis risk, the difference between $\tilde{B}_{t+i}$ and B_{t+i}. Without further information or restrictions, each separate risk cannot yet be measured.

Adding a commodity futures hedge and hold position with no exchange rate hedge eliminates the futures price risk component, leaving only exchange rate and commodity basis risk. The extent of futures price risk is now measurable by comparing eq. (7) to eq. (8) below.

$$MSE = \frac{\sum_{t=-i+1}^{T-i} [FP_{j,t} \times (X_{t+i} - X_i) + (B_{t+i} - \tilde{B}_{t+i})]^2}{T - 1} \quad (8)$$

To eliminate all of the risk from either the commodity basis or the exchange rates, consider the possibility of a perfect forecast for net price, NP, in eq. (1) similar in spirit to Kenyon and Clay's (1987) perfect foresight analysis. This eliminates short run price risk. Now consider perfect forecasts for each source of risk under the hedge and hold strategy, as shown in eq. (8). A perfect forecast for either of the variables in this equation would leave only one source of risk. This approach is applied to isolate basis risk by using a perfect exchange rate forecast.

The perfect exchange rate forecast changes the MSE with a commodity hedge-and-hold strategy to[3]

$$MSE = \frac{\sum_{t=-i+1}^{T-i} [B_{t+i} - \tilde{B}_{t+i}]^2}{T - 1} \quad (9)$$

[3]The MSE which results from adding a currency hedge to the commodity hedge is:

$$MSE = \frac{\sum_{t=-i+1}^{T-i} [FP_{j,t} \times \{(X_{t+i} - X_t) - (FX_{j,t+i} - FX_{j,t})\} + (B_{t+i} - \tilde{B}_{t+i})]^2}{T - 1}$$

which still leaves some residual exchange rate basis risk, $FP_{j,t}\{(X_{t+i} - X_t) - (FX_{j,t+i} - FX_{j,t})\}$ and commodity basis risk, $(B_{t+i} - \tilde{B}_{t+i})$. Including the commodity and currency hedge-and-hold strategy in the empirical test discussed below produces risk measures which are very similar to the perfect exchange forecast model used here.

Commodity hedging, combined with a perfect exchange rate forecast, provides a measure of basis risk [eq. (9)], since exchange rate risk and futures price risk are now zero. The proportion of total price risk accounted for from futures prices, commodity basis, and exchange rates can now be estimated by comparing eqs. (7), (8), and (9). The next section contains an empirical application of these risk measures to the Canada–United States cattle industry.

EMPIRICAL TEST OF RISK MEASURE

Canada has no public risk markets for cattle or for currencies, but these markets exist in the United States at the Chicago Mercantile Exchange. A test of this risk measurement procedure has a Canadian cattle investor (situated in Western Canada) purchase heavy feeder steers each month and place them in a custom feedlot for a three-month feeding period. The first feeder steers in the main part of the historical simulation are purchased in January, 1980 for sale in April, 1980. The last lot of heavy feeders are purchased in September, 1992 for sale in December, 1992. For simplicity, initial hedge ratios of one are used. Details on data sources and the historical simulation are available from the authors.

Net price received is calculated in Canadian dollars on each lot of cattle fed using the method described above. All forecasts are ex ante and out of sample and two different basis forecasts are used. The cattle pricing simulation compares a commodity hedge-and-hold or a commodity hedge with perfect exchange forecast to no hedging. The net price per hundredweight and the MSE of net price for the two basis forecasts are reported in Table I.

TABLE I

Net Price and MSE of Net Price per Hundredweight for Canadian Slaughter for 1980–1992[a] Using U.S. Risk Markets

	Mean Net Price December 1992 ($/cwt)	*MSE*	
		Updated Mean of Basis	*ARIMA basis*
No hedging—total price risk	103.27	76.82	71.50
Cattle hedge-and-hold	102.22	29.98	29.08
Cattle hedge-and-hold with perfect exchange rate forecast	—	29.88	28.84

[a]Prices are in Canadian dollars adjusted using the consumer price index to December, 1992 and the mean net price is the mean of slaughter prices received under each hedging strategy. Two different basis ex ante out-of-sample forecasts, using a simple updated mean and an ARIMA model are used. The U.S. commodity futures price adjusted using the spot currency rate is used to forecast the exchange-adjusted futures price in three months.

The MSE of net price (total price risk) changes from 71.5 to 76.82 depending on the basis forecast used. A commodity hedge-and-hold position reduces risk by 59% [(71.5–29.08)/71.5] when using the ARIMA basis forecast, and by 61% when using the updated mean basis forecast.[4] These results suggest that short-term cattle commodity hedges using the United States futures markets may be quite effective in reducing price risk. The MSE with a perfect forecast for the currency and a commodity hedge measures the residual basis risk. The remaining basis risk is about 39% of the total MSE risk when using the updated mean basis forecast. While basis risk is still significant, the results in Table I show that commodity hedging removes a large portion of the total price risk.[5] Comparison of the perfect exchange forecast result with the cattle hedge-and-hold suggests that exchange rate contributes less than 1% to total slaughter price risk and does not constitute a major price risk for short-term feeder cattle. The small additional risk reduction from a currency hedge may not be justified when transaction costs and discreteness of contracts are considered.

CONCLUSIONS

Investors using foreign commodities futures markets for hedging have futures price risk, local basis risk, and currency risk. Using the concept of a perfect forecast, one can separate and measure these three sources of risk using mean square error measures. The result is generally applicable to any foreign hedger where short-run risk is measured using MSE and price forecasts are derived from the futures markets. The decomposition is useful in measuring the relative contribution of different risk sources and developing risk management strategies. A historical simulation applying this method to three-month hedges suggests that Canadian cattle hedgers have relatively little exchange rate risk, that futures hedging removes close to 60% of the risk, and that basis risk is about 39% of total risk when commodity hedges are used.

[4]The commodity hedge reduces overall net prices by −1.04/cwt (with a standard deviation of $7.77/cwt) excluding transactions costs. These hedge returns are not, however, significantly different from zero. From this, one can conclude that a hedger would not routinely forecast commodity hedge profits, which justifies the price forecast models presented above.

[5]The commodity hedges reported in Table I use hedge ratios of 1. While relatively sophisticated models have been developed to calculate the variance-minimizing hedge ratio, a simple method to determine the hedge ratios is to do a search over the data (up to and including the information available at time t) to find the ratios that minimize the MSE. For the 1980–1992 time period, the MSE-minimizing commodity hedge ratios range from 0.90–1.0.

BIBLIOGRAPHY

Benninga, S., Eldor, R., and Zilcha, I. (1985): "Optimal International Hedging in Commodity and Currency Forward Markets," *Journal of International Money and Finance,* 4:537–552.

Boothe, P., and Longworth, D. (1986): "Foreign Exchange Market Efficiency Tests: Implications of Recent Empirical Findings," *Journal of International Money and Finance,* 5:135–152.

Braga, F. S. (1990): "On the Relation between Adjusted Basis and Hedge Results," *Canadian Journal of Agricultural Economics,* 38:323–331.

Brandt, J. (1985): "Forecasting and Hedging: An Illustration of Risk Reduction in the Hog Industry," *American Journal of Agricultural Economics,* 67:24–31.

Chrystal, K. A., and Thornton, D. L. (1988): "On the Informational Content of Spot and Forward Exchange Rates," *Journal of International Money and Finance,* 7:321–330.

Holt, M., Brandt, J., and Hurt, C. (1985): "Managing Risk with Forecasts and the Futures Market: An Application to Hog Production," *Journal of the Society of Farm Managers and Rural Appraisers,* 49:6–11.

Kenyon, D., Clay, J. (1987): "Analysis of Profit Margin Hedging Strategies for Hog Producers," *The Journal of Futures Markets,* 7:183–202.

Peck, A. E. (1975): "Hedging and Income Stability: Concepts, Implications, and an Example," *American Journal of Agricultural Economics,* 57:410–419.

Thompson, S. R., and Bond, G. E. (1987): "Offshore Commodity Hedging under Floating Exchange Rates," *American Journal of Agricultural Economics,* 69:46–55.

Wolff, C. C. P. (1988): "Exchange Rates, Innovations and Forecasting," *Journal of International Money and Finance,* 7:49–61.