SIMPLE AND MULTIPLE CROSS-HEDGING OF RICE BRAN

Emmett W. Elam, Stephen E. Miller, and Shelby H. Holder

Abstract

Feasibility of forward pricing sales of rice bran via cross-hedging was investigated. Corn, oats, wheat, and soybean meal futures were considered as simple and multiple cross-hedging media. Simulation results indicated that simple cross-hedging using corn futures would be most effective in reducing price risks.

Key words: rice bran, cross-hedging, corn futures.

Rice bran and millfeed are important by-products of the rice milling industry. On average, a hundredweight (cwt.) of rough rice yields approximately 71 pounds of milled rice, 10 pounds of bran, and 19 pounds of hulls. Bran and hulls are sold separately or are combined and sold as millfeed (or rice-mill by-product). Based on 1979-82 average prices, bran and millfeed sales accounted for only about 2 percent of the total value of products from 100 pounds of rough rice. On a national scale, however, the value of rice bran and millfeed production is substantial. Using the 1979-82 average rough rice millings of 145 million hundredweight, the value of rice by-products produced in an average year was approximately $50 million.

Rice bran and millfeed prices are variable both within and across marketing years. Arkansas prices can be used to illustrate how dramatically these price changes can be. For example, the September 1980 rice bran was $92.50/ton, but by September 1981, the bran price was $58.50/ton. During the period from September 1980 to January 1981, rice bran increased in value to $110/ton, but by April 1981, bran prices had fallen to $67.50/ton.

By-product price variability is a source of risk for rice millers. Consider the situation in which a forward contract for milled rice at a fixed price has been negotiated. Until the input has been purchased and the by-products have been sold, the miller is short in the rough rice market and long in the by-products. The branded rice miller who sells milled rice output at relatively stable prices, but purchases the rough rice input and sells the by-products at highly variable prices, also faces price risk. When to sell the by-products and when to price the rough rice input is a speculative decision based on the miller's judgment of the subsequent course of prices in light of the firm's disposition toward risk. The rough rice input can be purchased in the cash market and stored, bought on forward contracts from farmers, or hedged in rough rice futures trading on the Chicago Rice and Cotton Exchange. But until the by-products are sold, the milling margin is not set.

In the absence of futures markets for millfeed products, millers are faced with a problem if they desire to forward price their millfeed output. One alternative is to forward contract with feed mixers who use millfeed as ingredients or with livestock feed users. However, millers generally find that their opportunities for forward contracting without making price concessions are limited. Also, there is always a question of whether the other contracting party will meet its obligations.

Another alternative for rice millers is to cross-hedge their bran and millfeed output using the futures market for other commodities. Hieronymus has suggested in the case of wheat millfeed that wheat millers may forward price their millfeed production by using corn, oats, or soybean meal futures as cross-hedging vehicles. Since rice-mill by-products are substitute feed ingredients for wheat millfeed, feedgrain, and soybean meal, cross-hedges should also be appropriate. However, no empirical evidence as to the potential effectiveness of such cross-hedges has been offered. The objective of this paper

---

Emmett W. Elam is an Assistant Professor, Department of Agricultural Economics, University of Arkansas; Stephen E. Miller is an Associate Professor, Department of Agricultural Economics and Rural Sociology, Clemson University; and Shelby H. Holder is an Agricultural Economist, Economic Research Service, USDA.

is to examine the potential for both simple and multiple cross-hedging of rice bran. The objective is accomplished by comparing the risk associated with cross-hedging, using combinations of feedgrain and soybean meal futures, with the risk associated with an unhedged position. Subsequent sections provide a discussion of cross-hedging mechanics, an analysis of simulated cross-hedges of rice bran, and conclusions.

CROSS-HEDGING MECHANICS

Cross-hedging may be used as a risk management tool when direct hedging is not feasible. By definition, cross-hedging is the hedging of cash commodity positions by using futures markets for different commodities (Hieronymus). In its simple form, cross-hedging involves using the futures of only one commodity to offset a cash commodity position. Multiple cross-hedging involves the offsetting of a cash commodity position by using the futures of two or more different commodities. While direct hedging involves speculation in cash and futures price relationships for the same commodity (Hieronymus, p. 151), cross-hedging involves speculation in the relationship between cash and futures prices for different commodities.

A theoretical treatment of cross-hedging has been provided by Anderson and Danthine. Their analysis provides optimal decision rules for hedgers concerned with the mean and variance. These decision rules are used to examine how optimal cash and futures positions are affected by changing price expectations, production possibilities, and the number of futures used in a cross-hedge. There is only limited empirical evidence, however, regarding the feasibility of using cross-hedging as a risk management tool. Previous studies have dealt with the simple cross-hedging of wholesale beef cuts with live cattle futures (Miller, 1980; Miller and Luke; Hayenga and DiPietre, 1982b) and wholesale pork cuts with live hog futures (Hayenga and DiPietre, 1982a). The feasibility of multiple cross-hedging has been considered for the case of distillers dried grains with corn and soybean meal futures (Miller, 1982a). Miller (1982b) found that cross-hedging of feeder pigs with both live hog and corn futures was more effective than the use of only live hog futures.

Cross-hedging is more complicated than direct hedging on several counts. First, the appropriate futures commodity or commodities to be used for cross-hedging must be selected. The cash and futures commodities may be substitutes, complements, or some combination thereof. Also, the cash and futures may be associated as inputs and/or outputs of a production or marketing process. Partial correlations of the cash commodity price and a particular futures commodity price may be used to evaluate *ex ante* the potential usefulness of particular futures commodities as cross-hedging media (Anderson and Danthine).

After selection of the appropriate futures for cross-hedging, the amount of futures required to offset a cash position must be estimated. This is accomplished by estimation of the historic relationship between cash and futures prices in a regression framework. Let the estimated regression be represented as:

$$(1)\ \hat{CP}_t = b_o + \sum_{i=1}^{k} b_i \bullet FP^T_{i,t},$$

where $\hat{CP}_t$ equals the per unit predicted cash price at time t; $FP^T_{i,t}$ equals the per unit price at time t of the ith futures commodity contract maturing at time T where T is the contract maturity date nearest to, but not before, t ($T \geq t$); and $b_0, b_1, \ldots, b_k$ are estimated parameters. Seasonal differences in the price relationship may be measured by including seasonal intercept and/or slope shifters as additional regressors, as appropriate. The estimated regression coefficient for the ith futures, b_i, represents the units of the ith futures contract required to offset one unit of the cash commodity. (Note that b_i also indicates the change in CP_t associated with a unit price change of the ith futures.) For example, if the price of the ith futures is denominated in \$/bu. and the cash commodity price is denominated in \$/ton, b_i would indicate the number of bushels of the ith futures required to offset one ton of the cash commodity. If the estimated regression indicates a negative relationship between the cash price and a futures price, a short (long) cross-hedge would involve buying (selling) futures when the cross-hedge is placed. The indivisible nature of futures contracts complicates multiple cross-hedging. If QF_i is the quantity contract specification of the ith futures, only by chance could $(QF_1/b_1) = (QF_2/b_2) = \cdots = (QF_k/b_k)$. Thus, different contract multiples of the k futures would likely be required to obtain an approximate "balance" with the quantity of the cash commodity to be cross-hedged.

Target prices for cross-hedges to be lifted at time t+j (the date of cash millfeed sales) are calculated at time t by inserting the current prices of the futures maturing nearest to, but not before, time t+j into the estimated regression and solving for the predicted cash price. The target price may then be adjusted to reflect estimated hedging costs (round turn commissions and interest on margin). The target price equation for a short cross-hedge may be represented as follows:

$$(2)\quad TP_t^{t+j} = b_0 + \sum_{i=1}^{k} b_i \cdot FP_{i,t}^{t+j} - \sum_{i=1}^{k} |b_i| \cdot \widehat{HC}_i,$$

where TP_t^{t+j} equals the per unit target cash price for time t+j as calculated at time t; $FP_{i,t}^{t+j}$ equals the per unit price at time t of the ith futures contract maturing at time t+j; and $\widehat{HC}_i$ equals the estimated per unit hedging costs for the ith futures commodity.

The net price from a short cross-hedge is given by the actual price of the cash commodity at time t+j when the cross-hedge is lifted plus the gain from futures, less actual hedging costs; i.e.,

$$(3)\quad NP_{t+j} = CP_{t+j} + \sum_{i=1}^{k} b_i \cdot (FP_{i,t}^{t+j} - FP_{i,t+j}^{t+j}) - \sum_{i=1}^{k} |b_i| \cdot HC_i,$$

where NP_{t+j} equals the per unit net price of the cash commodity at time t+j; CP_{t+j} equals the per unit price of the cash commodity at time t+j; and HC_i equals the actual per unit hedging costs for the ith futures commodity. If the regression relationship between cash and futures prices holds exactly at time t+j, then

$$(4)\quad CP_{t+j} = b_o + \sum_{i=1}^{k} b_i \cdot FP_{i,t+j}^{t+j}.$$

If hedging costs are estimated correctly ($\widehat{HC}_i = HC_i$) and equation (4) holds, the net price from cross-hedging will equal the cross-hedging target price, as may be seen by substituting equation (4) in equation (3).

If the regression relationship does not hold exactly or the hedging cost estimate is incorrect, the target and net prices will differ. Note that the difference between net and target prices, or the error of the target price as a forecast of the net price, is independent of the futures price when the cross-hedge is placed, as may be verified by subtracting equation (2) from equation (3). Since the relationship between cash and futures prices is not deterministic, the target and net prices will only rarely be exactly equal; i.e., a basis risk remains. This basis risk is analogous to that encountered in direct hedging since the basis when the hedge is lifted is not known with certainty when the hedge is placed. A means of evaluating cross-hedging as a risk management tool is to examine the degree to which the target and net prices differ. If the target prices are not "good predictors" of subsequent net prices, cross-hedging may not be acceptable as a risk management tool.

CROSS-HEDGING SIMULATION

In this section, the results of simulated simple and multiple cross-hedges of rice bran are compared following the theoretical guidelines of Anderson and Danthine. In order to economize on data collection, it was assumed that bran sales were made at mid-month. Arkansas bran prices ($/ton) at mid-month, as reported in the USDA's *Weekly Rice Market News* , were used as the bran prices. The futures for oats, corn, soybean meal, and wheat were considered as cross-hedging vehicles. As noted previously, Hieronymus has suggested the use of oats, corn, and soybean meal for the hedging of wheat millfeed, a substitute for rice millfeed. Although wheat is mainly a food grain, it is also used as a livestock feed. The futures prices were those at closing on the trading day nearest the 15th of the month. January 1972 was chosen as the first observation in estimating cross-hedging levels, with 48 observations being included in the initial sampling interval for estimation of equation (1). Subsequent estimates were based on sampling intervals from January 1972 to time t. That is, the regressions used to determine cross-hedging levels were reestimated each month in the simulation using data available for that month.[1]

---

[1] Monthly intercept shifters (with January as the base period) were included as regressors to account for seasonal differences in the regression relationships between bran and futures prices. The results of simulations in which monthly slope shifters (with January as the base period) were also included as regressors did not differ appreciably from those reported in this paper.

TABLE 1. SUMMARY OF SIMULATED ARKANSAS RICE BRAN CROSS-HEDGES, 1976-82[a]

Simulation Number	Mean cross-hedging level				Rice bran net price[b]		Target prices as forecasts of net prices with cross-hedging[b,c]		Target prices as forecasts of cash prices without cross-hedging[d]	
	Corn	Oats	Wheat	Soybean meal	Mean	Variance	AFE_1	MSFE_1	AFE_2	MSFE_2
	bushels			tons	\$/ton	$(\$/\mathrm{ton})^2$	\$/ton	$(\$/\mathrm{ton})^2$	\$/ton	$(\$/\mathrm{ton})^2$
1	—	—	—	—	70.08	214.84	—	—	—	—
2	20.23	—	—	—	71.56	204.11	-0.84	100.25	-2.12	150.10
3	—	34.50	—	—	70.42	219.96	-5.87	183.72	-5.88	186.59
4	—	—	11.27	—	71.32	249.19	1.50	127.88	0.37	121.52
5	—	—	—	0.09	70.34	202.63	1.44	157.30	1.23	182.19
6	19.84	0.98	—	—	71.84	207.49	-0.50	103.35	-2.01	151.27
7	17.77	—	1.88	—	71.65	209.35	-0.64	101.04	-2.01	143.91
8	19.65	—	—	0.03	71.54	205.06	-1.64	102.12	-2.87	160.76
9	—	22.27	6.38	—	71.11	229.39	-3.59	129.90	-4.34	147.40
10	—	33.39	—	0.05	70.31	229.26	-6.88	200.71	-6.77	212.12
11	—	—	10.82	0.05	71.44	244.50	0.42	120.59	-0.79	128.65
12	14.86	4.79	2.42	—	71.78	214.05	-0.80	105.30	-2.25	144.83
13	18.43	2.76	—	0.04	71.59	210.89	-1.92	105.78	-3.17	163.01
14	17.31	—	1.80	0.03	71.59	210.03	-1.50	101.40	-2.80	153.61
15	—	22.26	5.97	0.04	70.87	234.78	-4.86	137.70	-5.36	164.12
16	13.60	6.42	2.36	0.04	71.52	217.92	-2.19	107.13	-3.37	156.34

[a] Number of simulated cross-hedges = 80.

[b] Target prices used as forecasts of net prices for simulation numbers 2-16 are inclusive of assumed hedging costs (round turn commissions and interest on margin accounts) of \$0.01/bu. for corn, oats, and wheat, and \$0.50/ton for soybean meal, as appropriate.

[c] AFE = average difference between net and target prices; MSFE = mean of the squared differences between net and target prices.

[d] AFE = average difference between cash and target prices; MSFE = mean of the squared differences between cash and target prices.

Eighty cross-hedges were simulated for each futures used as a cross-hedging vehicle, with the final cross-hedges being lifted in December 1982. Although alternative cross-hedging horizons from 1 to 12 months were simulated, only the results of the cross-hedges of 3 month's duration ($j = 3$) are reported. However, results for other horizons were similar.

Average forecast errors (AFE_1) and mean-squared forecast errors (MSFE_1) were calculated for each of the futures used singly for simple cross-hedging and for all combinations of futures used jointly for multiple cross-hedging. The AFE_1's may be used to determine whether target prices are biased forecasts of subsequent net prices. The MSFE_1's may be used to measure the risks associated with the divergence of realized net and target prices with cross-hedging. Following Peck, the mean-squared forecasting errors for the target forecasts (MSFE_2) provide measures of the uncertainty of subsequent rice bran cash prices faced by rice millers in the absence of cross-hedging.

The results of the simulations are presented in Table 1. Simulation number 1 indicates the results of cash-only sales. The simple cross-hedging results are reported in simulation numbers 2 through 5, and the multiple cross-hedges are reported in simulations 6 through 16. All of the cross-hedging simulations yield MSFE_1's which are smaller than the variance of cash prices. With the exception of simple cross-hedging with wheat futures, the mean-squared errors of target prices as forecasts of subsequent net prices (MSFE_1's) are also smaller than the corresponding mean-squared errors of target prices as forecasts of subsequent cash prices without cross-hedging (MSFE_2's). Among the cross-hedging strategies, simple cross-hedging using corn futures produced the lowest MSFE_1 and an AFE_1 which was not significantly different from zero at the 5 percent level.[2] Thus, corn futures would appear to be the appropriate mechanism for

---

[2] Statements as to statistical significance are based on appropriate F and t tests using 5 percent significance levels. The simulations which produced average differences between net and target prices (AFE1's) which were significantly different from zero were numbers 3 (oats), 9 (oats and wheat), 10 (oats and soybean meal), and 15 (oats, wheat, and soybean meal). These simulations along with numbers 8 (corn and soybean meal), 13 (corn, oats, and soybean meal), 14 (corn, wheat, and soybean meal), and 16 (corn, oats, wheat, and soybean meal) also produced average differences between target and cash prices without cross-hedging (AFE2's) which were significantly different from zero.

For simulations with negative AFE1's and AFE2's, care should be taken in using the target price because it overestimates the net price from cross-hedging and the future cash price without cross-hedging.

cross-hedging rice bran.[3] Values of R^2 for the equations used in the cross-hedging simulation using corn futures ranged from 0.70 to 0.78 over the sampling interval.[4] The average R^2 over the sampling interval was 0.73. The average correlation of corn futures and rice bran prices over the sampling interval was 0.75. Given an acceptable target price, the risks associated with the divergence of realized net prices and target prices is less than the risks found without cross-hedging, regardless of whether those risks are measured by the variance of cash prices or the mean-squared error of target prices used only as forecasts of subsequent cash prices ($MSFE_2$).

The use of only corn for cross-hedging purposes would also simplify the problem of "balancing" futures contract multiples. Corn futures quantities are 1,000 and 5,000 bushels on the Mid-American Commodity Exchange (MCE) and the Chicago Board of Trade (CBT), respectively. Using the mean cross-hedging level from simulation number 2, these contracts would be sufficient to cross-hedge rice bran quantities as follows: MCE corn—49 tons and CBT corn—247 tons. A "typical" two-shift (16-hours), 800 hundredweight per hour rice mill produces an average of 60 tons of rice bran per day or 300 tons per 5-day week. One CBT and one MCE corn contract would be sufficient to cross-hedge the weekly rice bran output of such a mill.

Although there were no significant differences in the mean net prices across simulations, the mean net prices from cross-hedging were generally higher than the mean net prices from cash sales only. This runs counter to expectations since the costs incurred in cross-hedging reduce mean net prices in simulation numbers 2 through 16. There were no significant differences in variances of net prices between simulations. Thus, routine cross-hedging would not result in reduced price variance from rice bran marketings. This result is in agreement with Tomek and Gray who have shown that for grains, distant futures prices are just as variable as nearby futures prices.

CONCLUSIONS

The objective of this paper was to evaluate the feasibility of cross-hedging rice bran sales. Results of simulated millfeed cross-hedges indicate that corn futures are appropriate for simple cross-hedges. Given an acceptable target price, millers would face less risks from divergent net and target prices with simple cross-hedging using corn futures than without. The risk associated with cross-hedging using corn futures was not reduced by multiple cross-hedging strategies involving other futures.

A limitation of the analysis is that only cross-hedges for mid-month sales were examined. The analysis could be extended by evaluating cross-hedges for sales made at different points during the month. Also, the data base could be expanded to include rice bran prices for other rice producing states. While the results in this paper should be representative of Southern locations outside Arkansas, they may not indicate the appropriateness of cross-hedging rice bran sales in California.

Suggestions for further research are the following. First, the analysis could be extended by simulating the use of cross-hedging by a rice miller. This would involve constructing a forecasting model for rice bran prices and developing *ex post* forecasts. Cross-hedges would be placed based on the relationship between the price forecast and the target price. The returns from alternative pricing strategies could be compared to selling on the cash market when the rice is milled. Second, the methodology in this paper could be used to evaluate cross-hedging corn gluten meal, cottonseed meal, and other feed ingredients for which there are not futures markets.

---

[3] Corn is the preferred cross-hedging commodity because rice bran is much like corn in terms of digestible protein content and has a TDN equivalent approximately 85 percent of corn. By contrast, wheat is primarily a food grain for which the price is based on its food value and oats are largely used in horse rations which represent a small portion of the commercial feed market. Consequently, wheat and oat prices are not so closely related to commercial feed prices as are corn prices. Soybean meal is used more as a protein supplement rather than a substitute for rice bran which has a lower digestible protein content (10-15 percent compared to 44-49 percent for soybean meal).

[4] For the majority of the regressions using corn futures, the Durbin-Watson statistics provided no evidence of serial correlation.

REFERENCES

Anderson, R. W. and J. P. Danthine. "Cross Hedging." *J. Pol. Econ.*, 89,6(1981): 1,182-96.

Hayenga, M. L. and D. D. DiPietre. "Cross-Hedging Wholesale Pork Products Using Live Hog Futures." *Amer. J. Agr. Econ.*, 64,4(1982a): 747-51.

____________ . "Hedging Wholesale Meat Prices: Analysis of Basis Risk." *J. Futures Markets.* 2,2(1982b): 131-40.

Hieronymus, T. A. *Economics of Futures Trading for Commercial and Personal Profit* (2nd Ed.). New York: Commodity Research Bureau, Inc., 1977.

Miller, S. E. "Beef Price Hedging Opportunities for Food Service Institutions." *J. Food Dist. Res.*, 11,1(1980): 29-34.

____________ . "Forward Pricing Distillers Dried Grains." *Feedstuff.* 54,16(1982a): 26-7.

____________ . "Forward Pricing Feeder Pigs." *J. Futures Markets.* 2,4(1982b): 333-40.

Miller, S. E. and D. B. Luke. "Alternative Techniques for Cross Hedging Wholesale Beef Prices." *J. Futures Markets.* 2,2(1982): 121-9.

Peck, Anne E. "Hedging and Income Stability: Concepts, Implications, and an Example." *Amer. J. Agr. Econ.*, 57,3(1975): 410-9.

Tomek, W. G. and R. W. Gray. "Temporal Relationships Among Prices on Commodity Futures Markets: Their Allocation and Stabilizing Roles." *Amer. J. Agr. Econ.*, 52,3(1970): 371-80.

U. S. Department of Agriculture, Agricultural Marketing Service. *Weekly Rice Market News.* various issues.