Hedging Effectiveness in a Vertical Marketing Channel

by

Dean Baldwin, Scott Irwin, Hassan Ahmed, and Rob Rye

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Introduction

A vertical marketing system is the physical and institutional structure that transfers a commodity from the producer to the final consumer. For the U.S. grain system, the vertical marketing channel includes transportation of grains from the farm level through intermediate handlers to points of export or to feed and grain processors. If the marketing system is competitive, then basis differentials between each market location will equal transportation costs, and short hedges may be effectively used in each market to manage price risk.

Although the issue of hedging effectiveness has been examined extensively in several previous studies, research has focused on only one market level and one time period [Ederington, Gray, 1981 and 1984, Kahl, 1985 and 1986, Garcia et al., 1986, Nelson, 1985, Tomek, 1970, and Wilson, 1984]. However, changes in government policies, transportation routes and rates, interest rates, carrying charges, local supply and demand relationships, international market conditions and/or weather conditions affect price discovery within a market, and hence hedging effectiveness, within the vertical marketing system. The effect of changing economic conditions and policies on the performance of the individual markets across a vertical marketing channel has not been examined in this context.

This study examines hedging effectiveness at selected levels in the vertical marketing channel for corn. Specifically, a portfolio hedging framework is used to measure hedging effectiveness for six markets in a vertical market channel, including a Gulf export market, Ohio River locations, Illinois River locations, and an inland location in Ohio. Differences in hedge performance measures for selected hedging periods in the crop year are compared across markets and for two time intervals, 1975-80 and 1980-86.

Procedures and Data

The theoretical framework for this study is the portfolio model of hedging proposed by Johnson and Stein (See Brown for a detailed exposition). In this framework, risk-minimizing hedges do not necessarily imply that the number of futures contracts sold equals the total holdings of the cash commodity, because spot and futures prices do not necessarily move in tandem [Brown, 1985]. The risk-minimizing hedge ratio is drived by minimizing the risk of a portfolio of spot and futures positions. The formula for the ratio is:

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$$\beta = COV_{sf}/\sigma^2_f$$

Where β = risk-minimizing hedge ratio

COV_{sf} = covariance of cash and futures prices

σ^2_f = variance of futures prices

Since the formula for β is the slope of coefficient for a regression equation, a regression of spot on futures prices yields an estimate of the risk minimizing hedge ratio. The "effectiveness" of hedging is measured by the R^2 from such regressions.

In this study, hedge ratios and hedging effectiveness measures are examined for six individual markets, including a gulf export market, Cincinnati and Louisville on the Ohio River, St. Louis, an aggregation of markets locations on the Illinois river and one inland location in Ohio (Figure 1). Since the inland location and the river elevators ship grain to the Gulf, these markets form a vertical market system. For the 1975 to 1986 period, weekly Thursday closing cash price data were collected for all markets except for the aggregated river locations in Illinois. Data were not available for the Ohio inland location for 1975-1978. Since data were not available for an individual river elevator in Illinois, Thursday's closing prices representing an average of four river elevators were obtained from the Illinois Livestock and Crop Market News Service. Thursday's closing futures prices, December, March, May and July contracts, were acquired from the Chicago Board of Trade.

Purchases and sales of corn are assumed to be made routinely, or in Working's terminology, elevators are merchandizing corn via an operational hedge. For example, corn purchased in October or November by an elevator in the vertical marketing system is assumed to be sold by December. This assumption is realistic as an inland elevator fills its storage facility at harvest, and thereafter routinely merchandises corn through the vertical marketing system. Delayed price and basis contracts are signed with farmers to facilitate the grain merchandizing function [Smith and Baldwin, 1984]. Similarly, river and export elevators do not perform the storage function [Larson and Baldwin, 1986]. Instead, their limited storage space is "turned" to perform the merchandizing function in an orderly and systematic manner [Larson and Baldwin, 1986].

For each hedging period and market, the weekly percentage change in cash prices at each individual market is regressed on the percentage change in the nearby futures prices. Percentage changes of prices were used instead of absolute price levels to minimize autocorrelation problems [Brown, 1985]. The Durbin-Watson test was used to determine if autocorrelation was present in any of the equations. If present, a Cochrane-Orcutt procedure was used to estimate autocorrelation-corrected parameters.

Regressions are estimated for two time intervals: 1975-1980 and 1981-1986. Differences in the magnitude of the hedge ratios across locations for each hedging period and time period are analyzed in terms of their respective "t" test statistic. To determine if the hedge ratios for the 1975-80 and 1981-86 time periods are statistically different, a dummy variable test is used [Gujarati, Marmer and Hill et al.]. The model is of the form

$$C_t = \alpha_0 + \alpha_1 D_1 + b_1 F_t + b_2(D_1 F_t) + e_t$$

where

α_0, α_1, b_1, and b_2 = parameters to be estimated,

D_1 = 1 if price data pertain to 1975-80,

= 0 if price data pertain to 1981-86,

C_t and F_t = cash and futures percentage price changes,

and e_t = error term.

Following the procedures developed by Gujarati, Marmer, and Hill et al., the hedge ratios for the two intervals (1975-80 and 1981-86) are considered to be the same if the differential slope coefficient, b_2, is statistically significant as indicated by the "t" test statistic.

To determine if the hedging effectiveness coefficients differed across markets and time periods, a confidence interval test [Neter et al.] is applied. Hedging effectiveness measures (R^2 values) are considered to be statistically different if their confidence regions do not overlap. The test involves the transformation of the sample correlation coefficient (the square root of the coefficient of determination) to a parameter Z' by

$$Z' = 1/2 \log_e(1+r/1-r)$$

As noted by Neter et al., when $n \geq 25$ the distribution of Z' is approximately normal with variance:

$$\sigma^2(Z') = (1/n - 3)$$

and the confidence limits are determined by

$$[Z' \pm Z(1 - \alpha/2)\sigma(Z')]^2$$

where $Z(1 - \alpha/2)$ is the $[(1 - \alpha/2)\ 100]$ percentile of the standard normal distribution. The hedging efficiency measures are compared for each location individually and between locations for two time periods.

Results

Hedge Ratios: Market Locations

In the vertical marketing chain, the magnitude of most hedge ratios declines as corn moved from the inland market via river markets to the Gulf market (Table 1). For the 1975-80 period, half of the inland market hedge ratios were also statistically equal to or greater than 1.00. Therefore, 50% of the time the inland market adopted a perfect hedge strategy. Except for the March-April and May-July hedging periods, the hedge ratios for both river and Gulf markets were less than one. Thus, the volume of corn that should be hedged (volume of long cash position increased) in these markets is less than what should be hedged in the inland market.

During the 1981-86 period, the inland market hedge ratios were statistically equal to one for all hedging periods. Although the hedge ratios for most river markets were somewhat smaller than for the inland market, more often than not the river hedge ratios were also statistically equal to one. In contrast, the Gulf market hedge ratios were all statistically less than one for this time period. These findings suggest that inland market and river prices were more efficiently tracking futures prices than were prices from the gulf market. Thus, hedging strategies adopted at different levels within the vertical marketing system would vary.

Hedge Ratios: 1975-80 and 1981-86

In response to changing economic conditions and policies, the hedging ratios increased for all markets in the vertical marketing chain (Table 1). The increase was statistically significant for the gulf market; thus the hypothesis that the optimal hedge ratios did not change between the two time periods is rejected (Table 2). For the markets on the Illinois River, the hypothesis is rejected for eight of the 12 hedging periods. For the Ohio Inland location, the hypothesis is accepted 50% of the time at the 10% level. For the Ohio River locations, the hypothesis is accepted more often than it is rejected. These results suggest the following: (1) The economic conditions and policies of the 1980s may have had a stabilizing effect on both futures and cash prices for some markets and hedging periods. Improving R_S^2 indicate that the respective cash prices were moving in tandem with futures prices. As export demand decreased, government intervention in the markets increased, and carry-over stocks increased, price relationships between cash and futures markets were stabilized. (2) The changes in policy and economic conditions of the 1980s had more effect on the gulf market than on the river and inland markets. This may reflect the specialized nature of the export gulf market as the river elevators and the inland elevators have multiple demands, transportation routes and rates, and often store grain for farmers and the CCC. (3) It is inconclusive whether the changes of the 1980s have had more effect on the river locations than on the inland location. The findings for the Ohio River locations vis-a-vis the inland market suggest a relatively larger impact for the river markets. This is not substantiated by comparing the findings for the Illinois River to that of the inland location.

Hedging Effectiveness: Locations

Hedging efficiency measures (R_S^2) are larger for the Ohio inland location than for the other market location (Table 3). However, for most hedging periods, the hypothesis that hedging efficiency measures are similar across locations is accepted (Table 4). These findings suggest that the markets in the vertical system were equally efficient in terms of their capability to offset cash price variance by selecting different hedging strategies. There is no evidence that one market is more efficient than another within a vertical marketing channel.

Hedging Effectiveness: 1979-80 and 1981-86

The hedging effectiveness measures appear to have increased for all markets and for nearly all hedging periods (Table 3). The hypothesis that the hedging effectiveness measure is not statistically different between the 1975-80 and 1981-86 time periods is accepted for five of the six hedging periods for the inland market and is inconclusive for the river markets and the Gulf (Table 5). For the reasons stated in the hedge ratio section of this paper, it appears that changes that occurred in the 1980s may have had a more stabilizing effect on river markets and the Gulf than on the inland market.

For the river markets and the Gulf, there may be one additional explanation for the rejection of the hypothesis. Statistically, the hedging efficiency measure improved for the Gulf and more often than not for the river markets during the winter months when the river system often freezes. This test may be capturing the effects of changing weather patterns as well as the potential increase in the instability of the export demand of the 1970s. The extreme cold weather of the 1970s caused the river system to remain frozen for long periods of time relative to what occurred in the 1980s. Therefore, the Gulf and river markets may have had difficulty meeting prior sale commitments during the 1970s and had to bid aggressively to move grain into the Gulf by other transportation modes, or through firms that were located on other rivers or transportation routes.

Conclusion

In this study, the vertical marketing channel for corn includes an inland location, river markets and an export port. The size of the estimated hedge ratios were directed related to the flow of grain in this channel being the largest at the inland location and the smallest at the gulf port. This implies that prices in the inland market were more effectively tracking futures than were corresponding prices at the other locations. This may have occurred because the inland location was less specialized than the other markets in the channel. Prices in the inland market were influenced by export, local processing and domestic feeding demands as corn was sold to local processors, feed mills in the southeastern U.S. and to river elevators for export. In contrast, prices in river elevators and at the gulf were more directly influenced by the export demand and changes in barge rates and weather conditions. Given that the supply of corn was known at harvest time, prices in the inland market may have been more sensitive to changes in demand because prices in the local market were directly influenced by a more diverse set of buyers. The hypothesis that the hedge ratios did not change between 1975-80 and 1981-86 was rejected for the gulf, was inconclusive for the river markets and was accepted for the inland market. Again, prices within the gulf market may have been influenced more by changing economic conditions and policies which diminished export opportunities. During the 1980s, many export plants in the gulf market were, in fact, closed.

The hypothesis that the hedging efficiency measures were not different across markets was accepted. By maintaining different hedge ratios, the markets are equally efficient in reducing cash price variance. During the 1975-80 period, the inland location could execute a near perfect hedge as the hedge ratio equaled one. In contrast, the river and gulf markets had to maintain a long net cash position. During the latter 1981-86 period, the inland location achieved hedging efficiency by maintaining either a perfect hedge or a small net short futures position. Most often, the river and the gulf markets could achieve hedging efficiency in the 1981-86 period by executing the perfect hedge. This suggests that hedging strategies may vary across markets and time periods.

The hypothesis that the hedging effectiveness measures were not different across time periods was accepted for the inland market and was inconclusive for the river and Gulf markets. Again, the specialized nature of the Gulf and river markets may have contributed to this finding as the marketing behavior of these firms is directly tied to export demand, barge rates and weather conditions on the river system.

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Figure 1: Selected Locations In A Vertical Marketing System for Corn

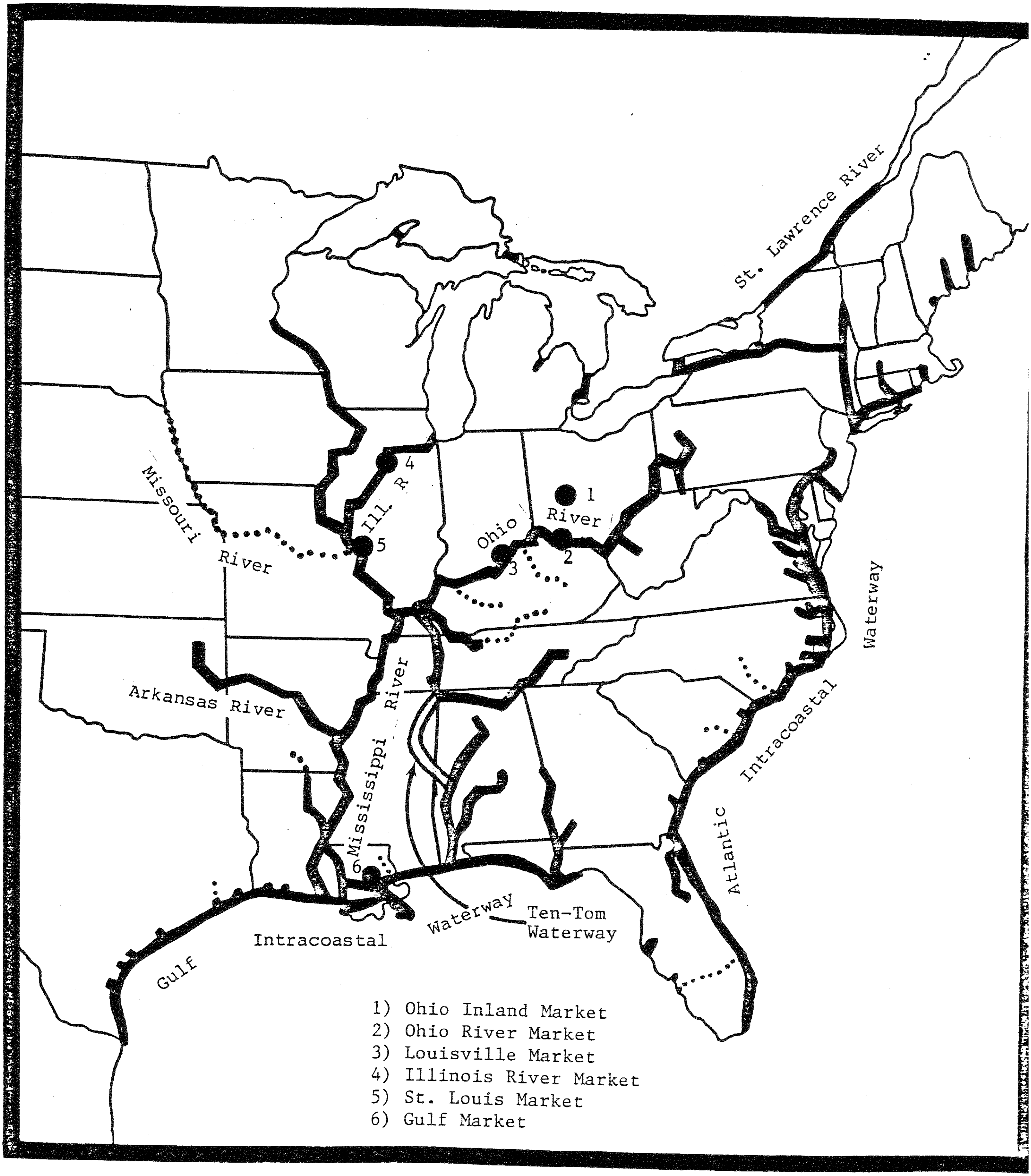

Table 1: Corn Hedge Ratios for Selected Locations and Periods, 1975-1980 and 1981-86.[1]

Market Locations	Ohio River Cincinnati	Ohio[2] Inland	Ohio River Louisville	Illinois River Locations	Illinois River St. Louis	Gulf
Hedge Periods						
October-December Hedge						
1975-1980	0.8182 (8.37)	1.0290 (9.41)	0.8020 (9.92)	0.8631 (5.02)	0.8322 (9.86)	0.7992 (16.61)
1981-1986	1.0585 (24.19)	1.1467 (27.8)	1.0712 (17.68)	1.034 (20.38)	0.9961 (21.64)	0.9206 (22.72)
December-January						
1975-1980	0.8794 (13.91)	1.1036 (21.99)	0.9111 (21.13)	0.9519 (16.16)	0.9540 (13.84)	0.7349 (16.96)
1981-1986	1.0348 (17.79)	1.1782 (17.58)	1.0523 (17.34)	1.0058 (17.89)	0.9260 (7.61)	0.9343 (17.41)
January-February						
1975-1980	0.8758 (13.29)	1.1080 (14.53)	0.9084 (15.11)	0.9373 (14.78)	0.8981 (12.44)	0.8400 (9.29)
1981-1986	1.0561 (26.20)	1.1680 (29.10)	1.1081 (31.36)	0.9907 (29.42)	1.0283 (12.40)	0.9883 (18.37)
February-March						
1975-1980	0.8078 (21.99)	0.9027 (26.71)	0.7939 (27.09)	0.8393 (16.16)	0.8182 (10.07)	0.6320 (6.73)
1981-1986	1.0287 (30.10)	1.1983 (33.36)	1.1502 (40.00)	0.9683 (24.48)	0.9357 (27.46)	0.8687 (21.75)
March-April						
1975-1980	0.9948 (9.43)	0.9536 (21.49)	1.0930 (11.80)	1.2250 (13.81)	0.9759 (11.26)	0.67765 (6.79)
1981-1986	0.9783 (20.37)	1.0411 (34.83	1.0080 (26.37)	0.9237 (26.94)	0.8955 (31.61)	0.8818 (33.45)
May-July						
1975-1980	1.0043 (21.48)	0.9144 (11.81)	0.9552 (14.44)	0.9791 (24.98)	1.0254 (29.26)	1.1985 (18.68)
1981-1986	0.9760 (28.32)	1.0191 (27.52)	0.9253 (17.60)	0.9863 (28.19)	0.9892 (27.87)	0.9285 (28.36)

[1] Number in parentheses represents the "t" statistics.
[2] The analysis for Ohio Inland market; first period covers 1978-1980.

Table 2: Statistical Difference in Hedge Ratios Between 1975-1980 and 1981-1986 for Selected Hedging Periods.[1]

Market Location	Ohio River Cincinnati		Ohio Inland		Ohio River Louisville		Illinois River Locations		Illinois River St. Louis		Gulf	
	α = 5%	α = 10%	α = 5%	α = 10%	α = 5%	α = 10%	α = 5%	α = 10%	α = 5%	α = 10%	α = 5%	α = 10%
Hedge Periods												
Oct.-Dec.	Sig.	Sig.	Sig.	Sig.	Insg.	Sig.	Insig.	Insig.	Sig.	Sig.	Sig.	Sig.
Dec.-Jan.	Insig.	Sig.	Insig.	Insig.	Insig.	Sig.	Insig.	Insig.	Insig.	Insig.	Sig.	Sig.
Jan.-Feb.	Sig.	Sig.	Insig.	Insig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Insig.	Sig.
Feb.-Mar.	Insig.	Sig.	Sig.	Sig.	Insig.	Sig.	Insig.	Insig.	Insig.	Insig.	Sig.	Sig.
Mar.-April	Insig.	Sig.	Insig.	Insig.	Insig.	Sig.	Insig.	Insig.	Insig.	Insig.	Sig.	Sig.
May-July	Insig.	Insig.	Insig.	Sig.	Insig.	Insig.	Sig.	Sig.	Insig.	Insig.	Sig.	Sig.

1 Sig. = Difference in Hedge Ratios is statistically significant.
Insig. = Difference in Hedge Ratios is statistically insignificant.

Table 3: Hedging Effectiveness Measures for Hedging Periods and for Selected Locations, 1975-1980 and 1981-1986

Market Locations	Ohio River Cincinnati	Ohio* Inland	Ohio River Louisville	Illinois River Locations	Illinois River St. Louis	Gulf
Hedge Periods						
October-December Hedge						
1975-1980	0.5343	0.7468	0.6171	0.3503	0.6143	0.8188
1981-1986	0.9055	0.9271	0.9083	0.5664	0.8847	0.8943
December-January						
1975-1980	0.8736	0.9738	0.9409	0.9031	0.8673	0.9113
1981-1986	0.9134	0.9115	0.9092	0.9143	0.6586	0.9099
January-February						
1975-1980	0.8548	0.9378	0.8838	0.8792	0.8376	0.7422
1981-1986	0.9581	0.9657	0.9704	0.9665	0.8400	0.9183
February-March						
1975-1980	0.9470	0.9834	0.9645	0.9063	0.7898	0.6264
1981-1986	0.9711	0.9763	0.9834	0.9568	0.9654	0.9460
March-April						
1975-1980	0.6448	0.9525	0.7395	0.7954	0.7214	0.4847
1981-1986	0.8944	0.9611	0.9341	0.9367	0.9532	0.9580
May-July						
1975-1980	0.8815	0.8279	0.7707	0.9096	0.9324	0.8491
1981-1986	0.9293	0.9254	0.8354	0.9287	0.9272	0.9294

Table 4: Hedging Effectiveness (R^2) Confidence Interval Evaluations Across Markets in the Vertical Marketing Channel for the October to December Hedge Period, 1975-80 and 1981-86.[1,2]

Location	Ohio Inland	Louisville	Illinois River	St. Louis	Gulf
Ohio River					
1975-1980	A	A	A	A	R
1981-1986	A	A	R	A	A
Ohio Inland					
1978-1980		A	R	A	A
1981-1986		A	R	A	A
Louisville					
1975-1980			A	R	A
1981-1986			R	A	A
Illinois River					
1975-1980				A	R
1981-1986				R	R
St. Louis					
1975-1980					A
1981-1986					A

[1] H_0 = Hedging effectiveness is not different between market locations at $\alpha = 5\%$ (A = Accept and R = Reject).

[2] Findings for the October-December hedging period are representative of the findings for the remaining five hedging periods.

Table 5: The Statistical Test for Hedging Effectiveness (R^2) Comparisons Between the 1975-1980 and 1981-1986 Time Periods for Different Locations in the Marketing Channel.[1]

Market Locations	Ohio River Cincinnati	Ohio Inland	Ohio River Louisville	Illinois River Locations	Illinois River St. Louis	Gulf
Hedge Periods						
October-December	R	R	R	A	R	A
December-January	A	A	A	A	R	A
January-February	A	A	R	R	A	R
February-March	A	A	A	A	R	R
March-April	A	A	R	R	R	R
May-July	A	A	A	A	A	A

[1] H_0: The hedging effectiveness measure is not different (α = 5%) for 1975-1980 and 1981-1986 (A = Accept and R = Reject).