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HEDGING YOUR ADVICE:
DO PORTFOLIO MODELS EXPLAIN HEDGING?†

Many actual and potential commercial uses of futures markets have been analyzed with portfolio-type decision models. In their earliest applications (see, for example, Johnson, 1960, and Stein, 1961), these models seemed particularly useful in integrating the risk-reduction descriptions of various firms' hedging strategies with the more descriptive multipurpose explanations of Working (1953). For example, with an optimal hedge, the amount to be hedged is determined by both returns and their perceived uncertainty. Thus, variation in the estimates of risks and expected returns provide an explanation of the observed variation in the extent firms choose to use futures markets. Applications of the model using estimates of returns and risks based on average past price changes and their variability and covariability have been widespread in both financial and agricultural markets and most recent work has emphasized continuous readjustment of the theoretically determined hedges with new estimates of variances and covariances of prices (see Carter and Loyns, 1985; Gordon and Rausser, 1984; Rolfo, 1980; and Thompson and Bond, 1985, for some recent applications in agricultural markets).

At the same time, there is surprisingly little empirical evidence to suggest that firms using futures markets regularly do so in ways that are described adequately by portfolio models. In a direct test, Rutledge (1972) related the (reportable) hedging of soybean processors (as proportions of their underlying positions in soybeans, soymeal, and soy oil) to traditional mean-variance measures of expected returns and risks. The results were

mixed, explaining reasonably well hedging of stocks but doing markedly less well in describing processors' hedging of products. Much more definitive are Hartzmark's (1987, 1988) analyses of an extraordinarily rich set of firm-specific data, the Commodity Futures Trading Commission's (CFTC) daily position reports of all large traders in several principal agricultural futures markets. First, his analysis showed that commercial firms earn substantial profits in their futures trading, a result which suggests that actual hedging strategies are not dominated by risk concerns and, combined with Williams' (1987) model of risk-neutral processors, shows that risk-aversion is not (and need not be) necessary to realistic models of commercial firm's behavior. Second, Hartzmark compared the positions of individual firms in the oats and wheat markets with risk-minimizing recommendations. For thirteen of the firms analyzed, actual positions were found to be significantly different from derived risk-minimizing positions, and Williams (1988) argued that a more appropriate statistical test would show even more of the firms to be hedging differently from the risk-minimizing strategy.

The present paper adds to the empirical evidence about hedging behavior, examining a long time series of reported cash and futures market positions of a representative sample of U.S. flour mills. The data are described below, with particular attention to the salient features of mill hedging. Price data are then used to determine the so-called optimal and minimum-risk positions according to the standard formulas derived from portfolio models. These recommended strategies are compared to actual firm behavior. Comparisons of recommended with actual hedges are irreconcilably joint tests, testing both a theory and its empirical representation. Nevertheless, the empirical representations are those commonly used in the literature. The results clearly indicate that mean-variance models have little descriptive content, from which one might conclude that there is considerable scope for improving firms' hedging practices. More likely, the portfolio model is simply inadequate.

FLOUR MILL OPERATIONS, 1964–79

For over fifty years (1925–79), the Millers' National Federation (MNF) collected data from member firms on their milling operations during the quarter and market positions at the end of each quarter, including stocks of wheat and flour, unfilled flour orders, and futures market positions. Although Working (1931) reports some early variability in the degree of the reports' coverage, MNF mills consistently accounted for approximately 70 percent of U.S. flour production (as reported by the Commerce Department) during the more recent 1964–79 period. Thus, the data represent a sizable and consistent sample of flour mills. MNF discontinued collecting the data on mills' operations in 1979 because they were largely duplicative

of Commerce Department series.[1]

Flour production is a continuous operation and varies little either seasonally or annually. Over 1964–79, MNF mills produced flour from an average of 103.7 million bushels of wheat per quarter. The quarterly grind ranged from 92 to 120 million bushels with a standard deviation of only 7 million bushels. By contrast, stocks of wheat (including flour stocks) and the amount of unfilled flour orders at the end of each quarter fluctuated dramatically. End-of-quarter stocks averaged 81 million bushels but ranged from half to about twice that amount. End-of-quarter, unfilled flour sales averaged 67 million bushels, approximately two-thirds the level of average output, but varied in a range like that of stocks.

The substantial variation in wheat stocks and flour orders against the backdrop of steady milling output suggests the potential for mills to use futures positions to balance physical market purchases and sales. The data in Table 1 summarize the average physical and futures market positions by subperiod 1964–71 and 1972–79. Even with the substantial end-of-quarter variation in the data, mills kept their average physical market positions fairly well in balance. In the 1960's, 90 percent of wheat stocks were covered by flour orders on average. In the 1970's, however, only 75 percent of stocks were covered. In both sub-periods mills used futures contracts to hedge much of the residual net cash market position, with the degree of coverage increasing to virtually 100 percent in the 1972–79 period. The futures positions show that the "average" MNF mill has both long and short futures positions on any specific quarterly date. This reflects both aggregation of individual firm positions and heterogeneity among the wheat markets. Wheat is not homogeneous, specific wheats are required for specific flours, and each of the three major wheat futures markets represent different wheats. Thus, a mill might be hedging stocks of soft red wheat in Chicago and hard wheat flour sales in Kansas City. Similarly, a mill might use different futures maturities to hedge its stocks and sales, depending on the timing of these commitments. Each decision depends as well upon the relevant price differences. Although important, these non-homogeneities are ignored in the analysis.

The standard deviations in the table are indicative of the substantial end-of-quarter variability in mills' positions. Much of this variation is seasonal.[2] For example, flour orders and wheat stocks both peak in the quarter following harvest and then decline regularly in the remaining quar-

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[1] Although MNF and the Commerce Department reported similar data on mill operations, the Commerce Department series does not include information on futures market positions. Thus, the present analysis was limited to the pre-1980 period.

[2] See Nahmias (1986) for the detailed analyses of seasonal patterns in the positions data.

Table 1.—Average End-of-Quarter Cash and Futures
Market Positions of MNF Mills, 1964–79*
(*Million bushels*)

Market positions	1964–71	1972–79
Physicals markets		
Wheat stocks	82.0	80.1
	(16.1)	(20.8)
Flour orders	73.7	60.1
	(25.0)	(23.2)
Net[a]	8.3	20.0
	(13.6)	(15.1)
Futures markets		
Short hedges	14.7	30.7
	(6.4)	(9.1)
Long hedges	9.0	11.3
	(5.1)	(6.9)
Net[a]	−5.7	−19.4
	(9.6)	(13.3)
Net unhedged market position	2.7	1.4
	(6.7)	(4.2)

* Based on data from Millers' National Federation (MNF), "Quarterly Stocks Reports," Washington, D.C., 1964–79. Standard deviations in parentheses.

[a] Net position calculated uniformly as purchases (long) minus sales (short).

ters. Long hedging fluctuates sympathetically while short hedging shows little systematic seasonality. Finally, the net hedged position does not vary seasonally, although it does vary considerably from quarter to quarter.

Flour millers' positions in futures markets may also be compared to other firms' hedging positions by the CFTC (formerly the Commodity Exchange Authority) regular reports of the positions of large traders. On the end-of-quarter MNF reporting dates, the CFTC's reported levels of hedging in Chicago, Kansas City, and Minneapolis were aggregated and then compared to the mills' positions. From 1964–71, mills accounted for an average of 19 percent of the total reported short hedging and 26 percent of long hedging. Over 1972–79, the mills' proportion of reported short hedging remained unchanged, while that of long hedging declined to 8 percent. Thus, the mills' use of wheat futures markets represented variable, but at times significant proportions of total commercial firms' positions.

The average extent hedged as reported in Table 1 also conforms in a

general way to implications of the portfolio theory. Price volatility increased dramatically in the 1972–79 period and the physical market positions of both bakers and millers were clearly altered. On average, bakers reduced their forward purchases of flour (mills' flour orders) in order presumably to keep their input costs more in line with the level and variability of output prices. Millers, however, did not reduce the average levels of their stocks; rather, they increased their use of futures markets and, simultaneously, increased the degree of overall coverage, reducing their average uncovered market position by almost one half.

THE DISTINCTIVE CHARACTERISTICS OF MILL HEDGING

In an earlier analysis, Working (1953) identified mill hedging as operational hedging, distinguishing it from storage hedging and anticipatory hedging on the grounds that it was motivated primarily by the ease with which buying and selling decisions could be made. The evidence for the distinction was primarily two-fold—millers' discussions of their hedging operations (see, for example, Bean, 1954; English, 1952; and Lake, 1953) and an analysis of mills' stocks responsiveness.[3] Mill stocks at the end of crop years were found to be unresponsive to conditions of overall market surplus and shortage, unlike stocks held for arbitrage purposes. The data in Table 2 update the contrast observed by Working and provide direct confirmation that mill stocks are not straight-forward storage arbitrages. The seven crop years from 1972/73–1978/79 were a period of substantial variation in year-end storage of wheat, dividing quite obviously into three years of comparative market shortage (1972/73, 1973/74, and 1978/79), three years of surplus (1975/76, 1976/77, and 1977/78) and an in-between year (1974/75). Free stocks[4] (stocks not owned by the CCC, under loan, or in the farmer-owned reserve) averaged only 343 million bushels in the shortage years and nearly twice that amount, 622 million, in surplus years. The market's return for hedged storage until year's end, measured by the carrying charge between old and new crop wheat futures in both Chicago and Kansas City, varied sympathetically, encouraging storage in surplus years

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[3] Working also identified and contrasted the behavior of so-called hedging and non-hedging mills. The distinction relied on observed differences in the behavior of their excess stocks. However, examination of the same relations with the much longer data series available here showed that his tentative results did not hold more generally and the distinction is not made. See Nahmias (1986) for details.

[4] Prior to the reintroduction of the loan program and the farmer-owned reserve in the mid-1970's, stocks under loan as well as those owned by the CCC were routinely subtracted from totals to obtain "free" supplies. Although the new programs contained explicit release provisions, their stocks were unavailable to the market for the most part and the intent here is to measure market stocks.

and discouraging storage in shortages. Millers responded not at all to the relative storage incentives; indeed, their average stocks increased slightly in years of shortage.

Although the data are not shown in the table, the millers' positions in wheat and flour did change. Forward sales of flour to bakers averaged 33.8 million bushels in the years of shortage and 51.0 million in years of surplus. That is, bakers adjusted by booking more flour forward in surplus periods than in shortage periods. Rather than adjust their inventories to the bakers' changes, millers increased the amount of futures sold to hedge the unsold stocks. Hedging of these stocks for lengthy periods is, of course, predictably unprofitable since periods of shortage are associated with inverse carrying charges.

Millers clearly accumulate wheat stocks and use futures contracts differently than traditional storage hedgers, reinforcing Working's distinction. Because the portfolio model has little to offer when the hedging operation is transparently motivated by arbitrage, the mills' behavior at least holds out the possibility for a successful test of the model. Evidently, the distinction also serves to simplify the decision problem for a portfolio analysis. The miller's uncertain return depends primarily on expected cash and futures price changes separately and not upon expected changes in the basis.

MILL HEDGING AS A PORTFOLIO PROBLEM

The question of interest is how well a standard portfolio model can explain the substantial variation in the extent to which mills hedged their net market position with futures. The hedging ratio of interest is:

$$\text{Mills' hedging ratio} = \frac{\text{net futures position}}{\text{net cash position}}$$
$$= -\frac{\text{short hedges} - \text{long hedges}}{\text{wheat stocks} - \text{flour sales}}.$$

If the periodic adjustments in the hedging ratios prescribed by the portfolio theory track the observed hedging ratios, the theory would seem to describe well. If the theoretical ratios move in the opposite direction or at different times than the observed ratios, the theory must be judged to perform poorly. The test compares quarterly movements in hedging ratios to the movement predicted by the theory. Following well-known procedures, the theory advises one of two ratios, depending on the constraints of the firm (see Kahl, 1983, for some derivations and comparisons). The ratios put forth in the literature are:

$$\text{Optimal hedging ratio} = -\frac{\sigma_{\triangle P}^2 * \triangle F - \sigma_{\triangle P \triangle F} * \triangle P}{\sigma_{\triangle F}^2 * \triangle P - \sigma_{\triangle P \triangle F} * \triangle F}, \quad \text{and}$$

Table 2.—The Relation Between Year-end Stocks of Wheat
in the United States and at Flour Mills and Carrying Charges
in the Wheat Futures Markets, 1973–79

Crop year	Carryouts June 1		Apparent free stocks	MNF mill stocks[b]	Carrying charges[c]	
	Total U.S.	In govt. programs[a]			CBT	KCBT
	(million bushels)				(cents/bushel)	
1972/73	599	212	387	68.6	−11.5	−8.3
1973/74	339	19	320	64.8	−3.0	4.0
1974/75	430	2	428	50.2	−0.5	−2.8
1975/76	665	21	644	64.3	8.0	6.0
1976/77	1,112	413	699	69.5	7.8	9.0
1977/78	1,174	652	522	65.8	3.0	3.3
1978/79	945	604	321	67.9	−8.5	−6.5
Average: 3 years of shortage			343	67.1	−7.7	−3.6
Average: 3 years of surplus			622	66.5	6.3	6.1

Sources: Various issues of U.S. Department of Agriculture, *Wheat Situation*, Washington, D.C.; Millers' National Federation (MNF), "Quarterly Stocks Report," Washington, D.C.; and Chicago Board of Trade (CBT) and Kansas City Board of Trade (KCBT), *Statistical Annual*, Chicago and Kansas City, respectively.

[a]Includes stocks owned by the Commodity Credit Corporation, under loan, and in the farmer-owned reserve. Specific dates vary, observation taken as close to June 1 as possible with information in *Wheat Situation*.

[b]Quarterly report date is June 30.

[c]The difference between May 1 closing prices of the July and May futures contracts.

$$\text{Minimum risk ratio} = \frac{\sigma_{\triangle P \triangle F}}{\sigma^2_{\triangle F}} \, ,$$

where $\triangle P$ and $\triangle F$ are the expected cash and futures price changes, $\sigma^2_{\triangle P}$ and $\sigma^2_{\triangle F}$ are the variances of the respective expected changes, and $\sigma_{\triangle P \triangle F}$ is their covariance. The ratios translate directly to percentages—a ratio of 1 is a hedging percent of 100.

To estimate either ratio, the most common approach has been to rely on past price behavior and that is the approach taken here. Because typical mill hedges are held very briefly, the variances and covariance are measured from daily data on price changes. Measurement of expected price changes is also required to calculate the optimal ratios and it is more problematic. In the basic results reported here, the mean of the price changes is used. However, a number of other variants were examined as well and their comparative performance is discussed. The positions are end-of-quarter observations (for example, March 30) and so the necessary estimates are taken from that month's prices (for example, daily price changes during March). Cash prices are for #2 ordinary protein hard red wheat in Kansas City, taken from the daily *Kansas City Grain Marketing News*. Futures prices are for the nearest contract not in delivery during the observation month (for example, prices of the May future during March for the March 30 calculation) and are from contracts traded on the Kansas City Board of Trade.[5] One can quibble with these procedures, but they are those most commonly used by advocates of portfolio analyses.

The primary results are summarized in Table 3, where average hedging ratios are presented as well as the correlation between the actual ratio and the minimum risk and optimal ratios. Initial regressions included quarterly dummy variables. These were never significant, individually or as a group. Moreover, the results were not sensitive to deleting outliers, for example, an optimal strategy of 350 percent. Results are presented both for the entire period and for subperiods.

Over the entire period, mills hedged an average of 75 percent of their net cash position, although the high standard deviation shows the actual quarterly ratios were quite variable. The average minimum-risk hedge was slightly more than 100 percent and, as might be expected, very stable. The average optimal ratio was approximately the same as the actual ratio but was substantially more variable than the actual hedging ratios. Most revealing, however, is the significant lack of relation between either the

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[5] Kansas City is still an active milling center and continues to have at least some cash grain trading. Chicago, by contrast, has virtually no active cash markets and cash prices reported are processor's bid prices at which there were almost never any transactions.

Table 3.—Comparison of Actual and Recommended
Hedging Strategies for Flour Mills, Quarterly 1964–79

Period/measure	Mean	Standard deviation	Degree of relation to actual hedging ratio (corrected R^2)
1964/65–1978/79[a]			
Actual ratio	0.75	1.79	——
Minimum risk ratio	1.05	0.13	−0.02
Optimal ratio	0.72	2.38	−0.02
1964/65–1971/72			
Actual ratio	0.58	2.45	——
Minimum risk ratio	1.08	0.15	−0.03
Optimal ratio	0.30	3.08	−0.03
1972/73–1978/79[a]			
Actual ratio	0.95	0.16	——
Minimum risk ratio	1.02	0.09	0.00
Optimal ratio	1.18	1.11	−0.04

[a]One observation is omitted because mills' net market position was zero and, of course, the hedging ratio undefined.

optimal or the minimum risk ratios and actual hedging percentages. The measures, the corrected R^2 from regressions of each recommended ratio on the actual ratio, are both negative showing that neither recommended strategy explained any of the variation in what mills actually did.

Similar results hold in each subperiod as well. In no case did predicted strategies bear any relation to actual hedging ratios. At the same time, the actual ratio increased from about 60 percent on average during the early period to nearly 100 percent in the later period, a change that is in accord with the predictions of a portfolio-type model. Prices were significantly more variable in the later period and mills hedged virtually all of their price risk.

Although not reported here, these results are not sensitive to which of several measures of price expectations that are used or even to their variability. In particular, optimal and minimum-risk hedge ratios were also calculated from weekly price change observations during the past quarter, and the average weekly change as well as actual 1-day, 1-week, and 4-week price changes were tested as proxies for expected changes.[6] In no case

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[6] See Peck and Nahmias (1986) for discussion of the results when weekly measures are used.

did the derived strategies explain actual strategies. Of course, some trans-position of the data not attempted might yield some explanatory power, but that chance would hardly be grounds for increased confidence in the portfolio model's recommendations.

CONCLUSIONS

Much theoretical research has been devoted to deriving hedging strate-gies, assuming firms are risk averse and thus that their use of futures mar-kets can be modeled as a mean-variance decision problem. Although this work has tended to validate the importance of futures markets in provid-ing useful, alternative marketing opportunities for firms, the present results strongly suggest these studies are only useful from the very broadest of per-spectives. The actual hedges of a set of firms that use futures markets reg-ularly were found to be unrelated to any portfolio-recommended strategy. The absence of any relation appeared to be very robust—no modification of hedging goals or construction of price expectations altered the results.

At a minimum, the results suggest analysts who are designing hedg-ing strategies for firms, or countries using a portfolio approach ought to hedge their recommendations considerably. In particular, so-called opti-mal strategies are extraordinarily sensitive to the specific calculation of price expectations, and none of the most obvious ones, including the actual one-day, one week, or one-month change, produced recommendations that behaved anything like actual strategies. Minimum-risk recommendations were least sensitive to specific assumptions, but neither did these reflect actual variation in hedging strategies.

Correlations among prices or price-changes have become a widely used measure of the degree to which individuals, firms, and even countries will find futures markets to be useful. In the present case, the high correlation between cash and futures price changes in the Kansas City wheat mar-ket can be taken to imply that mills will find futures markets valuable. Similar results have been used repeatedly to demonstrate the usefulness of futures markets to producers, yet in fact producers use futures markets only very rarely. By contrast, mills do use futures markets regularly, just not in ways derivable from the degree of correlation among prices. Combined with Hartzmark's firm-specific tests, these results ought to temper analysts' enthusiasm for trading strategies premised on risk aversion. Perhaps the theory is correct and the practitioners are wrong; but, that too is a du-bious proposition. Increasingly, analysis of the behavior of well-informed economic agents and, in the present case, analysis over a long period of time, are documenting profound differences between the theory and reality.

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