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PRIVATE STRATEGIES, PUBLIC POLICIES & FOOD SYSTEM PERFORMANCE

TESTING FOR RISK PREMIUMS IN THE WHEAT-FLOUR SUBSECTOR

by

Ronald W. Cotterill and Hachim M. Salih*

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* The first author is Professor and Director of the Food Marketing Policy Center, Department of Agricultural and Resource Economics, University of Connecticut, the second is a recent Ph.D., University of Connecticut and currently is Staff Economist, Islamic Relief Association, Los Angeles, California.

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ABSTRACT

This paper specifies a model of wholesale flour price determination that incorporates risk measures for input prices (wheat) and a joint output price (millfeed). Tests using daily price data for a Buffalo flour miller indicate that risk premiums do exist. Moreover, these premiums persist in a model that incorporates hedging.

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Introduction

The theory of the firm when input and/or output prices are risky is well developed. For the risk averse firm under general neoclassical conditions as input price risk increases demand for the input decreases, and as output price risk increases its supply of a product decreases (Sandmo, Turnovsky). Brorsen et al. adapted this theory to test for the existence of a risk premium in the wheat/flour subsector. Using aggregate, i.e. industry level, annual data dating from 1964 to 1982 for the U.S. they report that, inter alia, flour millers do incorporate a risk premium into flour prices. They subsequently argue that increased stabilization of wheat prices by programs such as the farmer owned grain reserve provide a hereto, fore unmeasured benefit, reduction of risk premiums in the flouring marketing channel (Brorsen et. al., p. 527).

This paper reports results for a similar analysis of risk premiums. The approach taken here, however, provides a more credible test for the following reasons. First, flour millers sell flour to bakery wholesalers on contracts that extend only for 60 to 120 days. Price quotes for these contracts vary daily. Therefore, the price risk that millers face is best captured by analysis of daily data for a firm at a particular location rather than annual aggregate U.S. industry price data. This study analyzes daily data for a one year period for a major flour miller located in Buffalo, N.Y.[1]

Second, Brorsen et al. assumed that flour prices were risky, when in fact the major

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[1] On the other hand, this study of a particular firm and location may not generalize to all firms and locations, but we know of no particular reasons that suggest this.

sources of price risk are variation in the input (wheat) price and variation in the joint output (millfeed) price. It is preferable to develop and analyze measures of wheat price risk and millfeed price risk, as is done in this paper. Wheat and millfeed price risks are not perfectly correlated, so a given risk level (e.g. variance) in output price can come from several different combinations of wheat and millfeed price risk levels.

Finally, there is a futures market where one possibly can hedge to reduce wheat price risk; but, there is no futures market for millfeed. In this paper we evaluate the effectiveness of hedging in wheat futures and evaluate the impact of covariance effects between wheat and millfeed prices on flour prices. These risk diversification effects have been ignored in prior research on risk premia.

II. Model Specification

Assuming that flour millers maximize expected utility of profits and that flour millers are price takers (i.e. the industry is effectively competitive)[2] a flour miller's choices when wheat and millfeed price are risky is as follows:

(1) $\max E[U(\Pi)] = E[U(P_f F + \tilde{P}_{mf} MF - \tilde{P}_w W - r'z)]$

s.t.

$$f(F, MF, W, z) = 0$$

where:

$U(\Pi)$	=	the utility of profits
P_f	=	price of flour
F	=	quantity of flour

2 Brorsen et. al. similarity assume a competitive industry structure (p. 522).

P_{mf} = price of millfeed

MF = quantity of millfeed

P_w = price of wheat

r = vector of other input prices

z = vector of other inputs

f(F,MF,W,z) = is the production function for the joint output of flour and millfeed from wheat and other inputs.

Tildes denote random variables.

This utility function U is assumed to be increasing ($U'(\Pi) > 0$) and concave ($U''(\Pi) < 0$) so this analysis focuses upon a risk averse firm. Moreover as Brorsen et.al. notes, the production function for the joint output of flour and millfeed is weakly separable between the wheat input and other inputs with a fixed proportion production technology holding the relationship between wheat input and outputs (1 unit wheat produces .725 units flour and .275 millfeed).

One can derive an empirically testable form of this model. If only an output price were risky it is identical to the Brorsen et.al. model. If only an input price were risky it is identical to Turnsovsky (1969) and Batra and Ullah (1974). Combining the two approaches in one and employing the fixed proportion production technology feature of flour milling one can derive a risk responsive supply function for flour and millfeed that has the following general form:

(2) $$F^* = F(P_f, \bar{P}_{mf}, \bar{P}_w, r, \sigma_{mf}^2, \sigma_w^2, \sigma_{wmf})$$

F^* is the joint output of flour and millfeed. This output is a function of the price of flour, the expected price of feed, the expected price of wheat, the price of other inputs (non wheat milling inputs), and three risk measures: the variance in millfeed prices, the variance in wheat prices, and the covariance of wheat and millfeed prices.

One can invert this function to a price independent form (Hein). Also recognizing that the output of flour and millfeed can be expressed as the quantity of wheat milled, and that in this short run analysis the prices of nonwheat milling inputs can be reasonably assumed constant one can obtain an estimable equation that is:

(3) $P_f = \beta_o + \beta_1 P_w + \beta_2 W + \beta_3 P_{mf} + \beta_4 \text{WRISK} + \beta_5 \text{MFRISK} + \beta_6 \text{COVAR}$

Hypotheses: $\beta_1 > o$ $\beta_2 < o$ $\beta_3 < o$ $\beta_4 > o$ $\beta_5 > o$ $\beta_6 < o$

where:
P_f = daily contract flour price announced by the mill

P_w = price of wheat

W = quantity of wheat milled

P_{mf} = price of millfeed

WRISK = wheat price risk measure

MFRISK = millfeed price risk measure

COVAR = covariance of wheat and millfeed prices

Assuming decreasing absolute risk aversion one can deduce the following hypotheses. The price of flour is hypothesized to be positively related to the price of wheat and negatively related to the price of millfeed.[3] In this short run model, the quantity of wheat milled expected to have a negative impact upon flour prices because demand is relatively stable and increased

[3] The Brorsen et al. model analyzed farm mill margins rather than flour prices, however on can obtain that margin in this model by subtracting $\beta_1 P_w + \beta_3 P_{mf}$ from both sides of equation 3. In our work we use the prior days price of wheat and millfeed as a measure of expected prices.

supply will depress price. The coefficients for WRISK and MFRISK are hypothesized to be positive and as such provide measures of the risk premia incorporated in flour prices. The coefficient on COVAR is hypothesized to be negative. If millfeed prices increase when wheat prices do, then the increased income from millfeed will offset some of the increased outlay for wheat, thereby providing some reduction in risk.

Hedging can be incorporated into this model by using the nearby futures price as the measure of P_w and the variance of observed basis risk as a measure of the net-of-hedging wheat price risk. Alternatively, one can use a measure of expected basis risk, termed the effectiveness of hedging ratio, which is the square of the correlation of cash and future price (Johnson, p. 215). Flour millers can price flour off the nearby futures by using a technique called operational hedging (English, Working). Basing their flour price on the futures, they hedge by buying nearby futures. Assuming no basis risk (i.e. a perfect hedge) they avoid all wheat price risk and their grain procurement department has time to assemble the grain needed to meet contract commitments.

III. Empirical Results

Data provided by a large wholesale distributor of bagged bread flour provides daily contract flour prices from September 11, 1986 to September 11, 1987 for patent bread flour, f.o.b. Buffalo, for a major flour miller. We were able to assemble from other sources, the corresponding Minneapolis cash and futures price for 14% hard spring wheat, and a weekly average millfeed price f.o.b. Buffalo. Daily millfeed prices were not available. Also the quantity of flour milled in Buffalo was not available, however we were able to obtain a monthly mill output rate for the U.S. as a proxy for short-run supply pressure on prices.

Price risk measures were computed using a 20 day weighted moving average variance with the most recent day receiving a weight of 20, the previous day 19, the next 18 etc.[4] A measure of Johnson's hedging effectiveness ratio was computed for each day by computing the squared correlation coefficient for cash and futures prices for this preceding 20 days. Similarly the covariance measure for wheat and millfeed was computed using a 20 day moving average formula.

Table 1 reports the descriptive statistics for the sample. Patent bread flour prices averaged $14.85 per cwt. and ranged from a low of $13.56 to a high of $15.91 during the year. Wheat futures, wheat cash, and millfeed prices also exhibit considerable variation. Basis is negative with an average value of -$.607 and ranges from -.89 to -.31. Thus the Minneapolis price for 14% protein hard wheat, a high quality wheat, is consistently above the Minneapolis futures price. This inverted basis does not preclude hedging. The effectiveness of operational hedging depends on how closely the two price series are correlated, i.e. the existence of a stable basis relationship. Looking, however at the observed variation in basis and E, the effectiveness of hedging ratio, it appears that hedging conditions are considerably less than perfect. Recall that E is the square of the correlation coefficient between cash and futures. If E is near 1 than hedging is nearly perfect. If it is near zero, hedging does little to reduce price risk. In this sample E averages .62 and ranges from effectively zero to .97. At some times in the year hedging is not effective, but at others it is very effective as a risk reducing mechanism.

The 20 day weighted moving average variances for cash wheat price, millfeed price, and

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[4] For mill feed prices the reported week's average price was used for each day in the week and the daily weighted moving average variances were computed on this series. Theory provides no guidance for choosing the length of the period or the weight. We tried other measures, and our qualitative results are not sensitive to the computation of risk measures.

basis also indicate that variation in these risky prices is not constant over the time period. Riskiness fluctuates as well as expected prices. Similarly there is considerable variation in the measures of the covariance of wheat and millfeed prices.

Table 2 reports estimation results. All equations are corrected for autocorrelation by using the Cochrane Orcutt procedure. Equation 1 indicates that cash wheat prices are a positive and highly significant determinant of flour prices as hypothesized. The quantity of wheat milled in the U.S. during the month, also behaves as hypothesized with a negative coefficient that is not quite significant at the 5 percent level. Our measure of wheat price risk, the 20 day weight moving average of cash wheat prices is positive as hypothesized but not significant. Equation 2 introduces the Buffalo millfeed price and the millfeed price risk variables to the model. Their addition dramatically improves the model, increasing the significance of the cash wheat price variable, establishing the significance of the wheat quantity variable at the 1 percent level. Buffalo millfeed price is negatively related to flour price as hypothesized and is highly significant with a t-ratio of 16.8. The cash variance measure of wheat price risk continues to be positively related to flour price and is now significant at the one percent level. Flour prices appear to contain a risk premium related to cash wheat price fluctuations. Our measure of millfeed price risk and the covariance of wheat and millfeed prices, however do not perform as hypothesized. The 20 day weighted moving average variance for millfeed prices is negatively related to price and significant at the 5 percent level. The covariance term also has the wrong sign (positive) but is not significant. With a regression R^2 of .77 and total R^2 of .82. This model explains a significant proportion of the observed variation in flour prices, but these are not high R^2 for time series analysis.

Table 1. Descriptive Statistics (252 observations)*

Variable	Mean	Standard Deviation	Minimum Value	Maximum Value
FLOUR PRICE (cwt.)	14.8568	0.5321	13.5600	15.9100
WFUTURES	4.4958	0.1500	4.2083	4.8875
WCASH	5.1047	0.2073	4.6042	5.7333
MILLFEED (cwt.)	2.4259	0.5613	1.3200	3.3000
BASIS	-0.6092	0.1144	-0.8917	-0.3167
WQTITY (U.S. monthly)	65.6593	2.6775	61.5810	71.1130
VAR20CSH	0.0112	0.0095	0.0011	0.0510
VAR20MILL	0.0414	0.0494	0.0016	0.2597
VAR20BAS	0.0044	0.0036	0.0004	0.0181
COVMILL/FUT	-0.0005	0.0115	-0.0215	0.0509
COVMILL/CASH	-0.0020	0.0147	-0.0358	0.0584
COVMILL/BASIS	0.0015	0.0080	-0.0175	0.0264
COVMILL/E	0.0008	0.0052	-0.0123	0.0342
E	0.6200	0.2837	0.0001	0.9670

* All wheat prices are for hundredweight flour equivalents (2.3 bu.)

Table 2. Contract Flour Price Determination Models [a]

	Wheat Price Measure	Wheat Price Result	Wheat Quantity	Mill Feed Price	Wheat Risk Measure	Wheat Risk Result	Mill Feed Risk (20 Day Var.)	Covar Millfeed/Wheat Measure	Covar Millfeed/Wheat Result	Intercept	Reg R^2	Total R^2
1.	CASH	1.3333	-.0145		Var 20	2.8070				8.9718	.4456	.7800
		(13.791)*	(-1.645)		Cash	(1.462)				(11.345)*		
2.	CASH	1.5486	(-.0394)	-.5670	Var 20	11.0586	-.6532	Millfeed	1.5798	10.8268	.7736	.8261
		(19.286)*	(-5.891)*	(-16.802)*	Cash	(6.494)*	(-1.805)**	Price Cash Wheat	(1.515)	(16.532)*		
3.	FUTURES	1.4863	-.0081		Hedge	.0169				8.6426		
		(12.014)*	(-.902)		Effect (E)	(.352)				(10.993)*	.370	.8111
4.	FUTURES	1.6870	-.0246		Var 20	10.578				8.8275		
		(11.245)*	(-2.555)*		Basis	(1.796)**				(9.237)*	.3592	.7123
5.	FUTURES	1.7064	-.0375	-.4382	Hedge	.0779	.4990	Millfeed	-1.3021	(10.6330)		
		(14.227)*	(-4.720)*	(-10.766)*	Effect(E)	(1.527)	(1.558)**	Price, E	(-.411)	(13.766)*	.6058	.8251
6.	FUTURES	1.8782	-.0410	-.4551	Var 20	2.0471	.6011	Millfeed	2.0365	(10.1690		
		(15.221)*	(-5.309)*	(-10.842)*	Basis	(.417)	(1.717)**	Price, Basis	(1.200)	(12.886)	.6353	.8069

[a] 252 observations in sample. GLS results (corrected for autocorrelation) are reported.
* Significant at 1% level.
** Significant at 5% level.

Equations 3 through 6 in Table 1 report estimation results for models that assume the firm hedges to reduce wheat price risk. In equation 3 wheat futures price is positive and significant as hypothesized. The quantity of wheat milled in the U.S. during the month has the hypothesized negative sign but is not significant. Johnson's measure of hedging effectiveness, E, was hypothesized to be negatively related to flour prices: it is positive but not significantly different from zero. Equation 4 introduces the 20 day weighted moving average variance of basis as the measure of basis risk for a hedged flour miller. It is positive as hypothesized and significant at the 5 percent level.

Equation 5 introduces millfeed price, millfeed price risk and the covariance of millfeed price with the effectiveness of hedging measure. As with the cash wheat models their introduction dramatically improves the model. Wheat futures price, wheat quantity, and millfeed price have the hypothesized sign and are significant at the one percent level. The effectiveness of hedging continues to have an expected positive sign, but it is not significant at the 5 percent or better level. The millfeed price risk variable is positive as hypothesized and significant at the 5 percent level. The covariance of millfeed price and hedging effectiveness is negative as hypothesized but not significant.

Equation 6 gives similar strong results for wheat futures price, wheat quantity and millfeed price. The variance of basis is positive as hypothesized but not significant. Millfeed price variance has the hypothesized positive sign and is significant at the 5 percent level. The covariance of millfeed and basis does not have the hypothesized negative sign and is not significant.

Summary and Conclusions

These results provide at best weak support for the hypothesis that flour millers factor a basis risk into the pricing equation, and thus suggest that operational hedging has little impact on flour prices. In the best hedging model (equation 6) there is no risk premium associated with variance in the basis for wheat, but a weak premium seems to exist for risk in the millfeed market. Possibly hedging is occurring and the firm enjoys near perfect hedges so the variance in basis is so small that it is not a significant factor in the firm pricing. As we noted, however, when discussing the descriptive statistics contained in Table 1, there is considerable variance in basis, and the effectiveness of hedging ratio. Thus near perfect hedging conditions do not exist, and this special case can be ruled out.

On the basis of goodness of fit the cash wheat price models seem to do a little better than the hedging models. In the best cash wheat price model, wheat prices, wheat quantity milled, and millfeed prices are the strongest determinants of flour prices. Flour prices also are positively and strongly related to wheat price risk as measured by the weighted 20 day moving average variance of cash prices.

Further research might explore the robustness of these results during different periods of the marketing year. The model may perform differently, for example, during harvest as opposed to the storage months. The results reported here and this suggested extension can certainly be useful for firms selling and buying flour, and possibly for agricultural policy decision makers who wish to devise grain reserve release rules that reflect not only the existence of a risk premium in the wheat-flour subsector but also its sensitivity to time of year.

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Professor Ronald W. Cotterill, Food Marketing Policy Center.
Department of Agricultural Economics and Rural Sociology
Box U-21
The University of Connecticut
Storrs, Connecticut 06269-4021
Tel. No. (203) 486-4394