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An Alternative Measure of Price Risk on Aggregate

Sow Farrowings, 1973-86.

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ABSTRACT

Aggregate sow farrowing response to price risk is estimated where price risk is defined as the difference between expected and realized price in asymmetric (unfavorable deviations) and symmetric (favorable and unfavorable deviations) forms. Asymmetric risk was found to be statistically more significant than symmetric risk using cash or futures prices.

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Output decisions by primary producers are characterized by uncertainty regarding both price and environmental factors. Acreage responses to price risk have been measured as deviations from an expected price (Just and Traill). An alternative measurement of risk is the deviation of returns from a target return (Fishburn, Holthausen). Risk in hog production results mainly from input and ouput price uncertainty (Hurt and Garcia). The existence of futures markets for both hogs and corn may imply decreased price uncertainty, but producers have been reluctant to hedge using the futures market (Leuthold). However, price information provided by the futures market may still be utilized in the formation of price expectations.

Modeling of risk relies critically on the accurate specification of decision timing and of the producer's risk perception. Hurt and Garcia characterized price risk in sow farrowings as the positive or negative deviation of realized prices from expected prices. Their symmetric price risk (SPR) measure contrasts with an asymmetric price risk (APR) measure tested for in this analysis. The next section of this paper describes the APR and SPR measures analyzed for the cash and futures markets and is followed by a section outlining the price risk models and estimation procedures. Empirical results of the conventional no risk, APR, and SPR models are then presented for both the cash and futures markets. Some concluding remarks are offered in the final section.

Price Risk Measures Considered

This study looks at price risk as being the difference between an expected price at decision time and the realized price at acquisition or selling time. Only differences which are unfavorable (i.e. realized acquisition price of input greater than expected input price at decision time or realized sale price of output less than expected sale price at decision time) are included in the APR models. When realized price is more favorable than expected price at decision time a value of zero is assigned to the price risk measure. In the SPR models, both favorable and unfavorable differences are included in the price risk measure for input(s) and output(s). APR is considered more theoretically appealing than SPR since SPR includes deviations where realized prices are more favorable than past price expectations. If expected prices are used to determine an entrepreneur's target return, the APR models are equivalent to a form of Fishburn, or Holthausen's framework of risk being associated with deviations below a target return since hog production is essentially nonstochastic. Both APR and SPR measures were weighted by squaring or taking the absolute value of their associated price differences.

Since corn is the main input in feeding hogs, the price of corn and the output price of hogs are quantified in this study to capture the price risk associated with all inputs and outputs in the hog production process. The expected prices of corn and hogs were generated using either the futures or cash market prices. Since the time lag between breeding and the actual sale of hogs is about four quarters, hog price risk is defined as the difference between the expected price in t minus the realized price in t+4. Corn price risk is defined as the difference between the expected price in t minus a weighted (.15, .2, .25, and .4, respectively) realized price in t+1, t+2, t+3, and t+4. Weights are given to approximate the associated feed requirements for the sow and litter between the time of breeding and slaughter sale.

Expected prices for corn and hogs in the futures market were calculated as the average of the futures prices[1] for t+1, t+2, and t+3 in period t (i.e. Futures Price Spectrum in t (FPS_t)). The realized price for corn and hogs is the futures price at maturation. Futures prices for t+4 in period t were not included in FPS_t because of missing observations for many months. Also, the futures market is relatively thinly traded in t+4 compared to nearer quarters so that the use of a single observation (which sometimes had to be determined by extrapolation) resulted in substantially more price variability than for the other quarters and a potentially detrimental bias. An average of t+1, t+2, and t+3 in period t was used to generate expected futures prices since it was felt that producers respond more to a spectrum of forward prices than a single futures price. The equivalent to the FPS_t for determining price risk in the cash market was defined as the cash price for hogs (corn) at four quarters prior to expected sale (acquisition) time.

Price risk measures were weighted by squaring the price deviations and by taking the absolute value of the price deviations to determine if producers weight larger price deviations significantly different than smaller price deviations. Only the squared deviations are reported in this paper since the results of the two measures were quite similar. Cross price risk between corn and hogs was also considered in this analysis in multiplicative and additive forms for the squared and absolute risk models respectively, but was found to be statistically insignificant in both forms for the cash and futures markets.

Model Specification and Estimation Procedures

Sow farrowings in period t ($SFAR_t$) are specified with the addition of symmetric or asymmetric price risk to the conventional variables of a constant term, seasonal dummy variables, time trend, input price and output price.

Input price, output price, and price risk measures are included in the contemporaneous and lagged periods (t-i; i=0 to m) to capture the simultaneous and dynamic quantity interactions between corn and hog prices and price risk. A more explicit description of the variables in the conventional, symmetric risk, and asymmetric risk models are given in table 1.

The biological production lag and high capital costs associated with hog production are felt to delay most of the quantity response in sow farrowing by at least two to three quarters. Therefore, all models were estimated by using a second order Almon-polynomial distributed lag. A third order Almon-polynomial was tried on some preliminary estimates and found to have little or no change on estimated parameters and statistical significance.

It was also felt that the corn price, hog price and price risk measures would have the same significant lag length since the significance of all these variables is being influenced by the same biological production process. Therefore, the Schwarz Criteria (SC) was used to determine the lag length for hog price, corn price, hog price risk, and corn price risk under the presumptions of; 1) a second order polynomial distributed lag on all these variables, 2) the same significant lag length on these variables, and 3) that the true lag length (m) is no greater than 22 quarters. The SC was chosen since there is Monte Carlo evidence suggesting that the SC is clearly favored for small and moderately sized samples (Judge, et al). To determine the significance of the expected prices and price risk coefficients (t-i; i=0 to m) an F test was made for the sum of the coefficients (i.e. $\sum_{i=0}^{m}\beta_j$'s) against the fully specified model. The significance of the price risk for corn and hogs is reported individually and jointly using this procedure.

Empirical Results

The estimated results for the conventional cash (CC), conventional futures (CF), SPR cash (SPRC), SPR futures (SPRF), APR cash (APRC), and APR futures (APRF) models are presented in table 2. Statistical results of the conventional models (CC and CF) are inferior to those incorporating risk. The Durbin-Watson statistics are very low (1.296 and 1.144, respectively) for the CC and CF models, indicating that positive autocorrelation is present. It is generally acceptable to correct for autocorrelation using the Cochrane-Orcutt procedure or an equivalent procedure, but it may be more appropriate to determine whether the model is correctly specified before correcting for autocorrelation. The Durbin-Watson statistics and the adjusted coefficients of determination improved substantially when price risk for hogs and corn was added to the conventional model specifications.

Statistical results of the APR and SPR models do not show overwhelming evidence as to which price risk measure is superior but the individual and joint F-values for the hog and corn price risk variables suggest that the APR measure is preferred. F-values for the joint risk test are about twice as much (4.85 vs. 7.76 and 7.33 vs. 15.37, for SPRC vs. APRC and SPRF vs. APRF, respectively) for the APR measures as they are for the SPR measures. The APR measures are also more significant individually than they are for the SPR measures in both markets. These significance levels suggest that producers are more likely to respond to adverse price deviations rather than responding symmetrically to both favorable and unfavorable price deviations around an expected price.

Long-run elasticities for own price, input price and price risk which measure the responsiveness of producers to these factors are presented in table 2. Elasticity estimates changed only fractionally when variables insignificant at the .05 level were eliminated, so discussion of these estimates will rely primarily on variables that are at least significant at the .05 level. Hypothesized signs of positive for hog price, and negative for corn price and the price risk variables were realized for all of the models except for the price risk of hogs in the SRF model. The own price elasticity estimates are more elastic for both the cash and futures models with the inclusion of APR or SPR. This suggests that the omission of price risk substantially biases the output responsiveness to own price changes downward. Such bias could lead to quantity responses that are substantially underestimated from the implementation of a policy which placed an effective floor price on hogs.

Input elasticity estimates changed less consistently with the inclusion of risk than the changes of the own elasticity estimates. That is, the elasticity estimates became more elastic for the APRC model but less elastic for the SPRC, SPRF, and APRF models. Corn price risk elasticity estimates are substantially greater than they are for hog price risk, implying that hog producers are responding more to input price uncertainty than they are to output price uncertainty. Corn price risk effects are probably more influential than hog price risk effects because corn production is subject to more stochastic variables (e.g. weather) than hog production. Corn is also a primary export product so that corn price is subject to more international trade uncertainty and conditions than hog price.

Concluding Remarks

An alternative form of measuring price risk was formulated in this study by considering an APR measure which includes only unfavorable deviations between expected price and realized price. This APR measure is in contrast to the SPR measure of price risk analyzed by Hurt and Garcia which includes both unfavorable and favorable deviations between expected and realized prices. Results of this study indicate that these deviations are very robust in being an influential variable to the quantity response of sow farrowings whether they are included in asymmetric-absolute, asymmetric-squared, symmetric-absolute, or symmetric-squared in either the cash or futures markets. However, the APR form came out statistically more significant than the SPR form for all of the cases analyzed in this study.

Exclusion of price risk was found to substantially bias downward the own price elasticity effects for hogs. Policy decisions related to the price of hogs which are based on a conventional riskless model would most likely result in underestimated quantity response effects. The results of this study also have policy implications in regards to price floors and price ceilings set by government policies. These results imply that there would be an upward shift in the supply of hogs if the government were to remove some adverse price risk for hogs (corn) by use of a price floor (ceiling). In general, supply response studies which neglect to incorporate price risk are likely to result in policies which inaccurately predict producer responses. Risk measures presented here should have applications in further research attempts at modeling aggregate supply response.

FOOTNOTES

1. Quarterly futures price spectrums were arrived at by taking the average of the three months futures price spectrums within a quarter. Linear interpolation was applied between futures contracts if a month did not have a futures quote for a period 3, 6, or 9 months in the future. The week-ending futures prices closest to the 15th of each month were used.

Table 1. Specification of Conventional and Price Risk Models of Aggregate Sow Farrowings Using Cash and Futures Prices.

Model (j)

(j=1; conventional cash)

$$CC; \quad SFAR_t = SEAS_{jt} + \sum_{i=0}^{16} [\beta_{jhi} CPH_{t-i} + b_{jci} CPC_{t-i}]$$

(j=2; conventional futures)

$$CF; \quad SFAR_t = SEAS_{jt} + \sum_{i=0}^{17} [\beta_{jhi} FPSH_{t-i} + \beta_{jci} FPSC_{t-i}]$$

(j=3; SPR-cash)

$$SPRC; \quad SFAR_t = SEAS_{jt} + \sum_{i=0}^{17} [\beta_{jhi} CPH_{t-i} + \beta_{jci} CPC_{t-i} + \beta_{jrhi} SCHR_{t-i} + \beta_{jrci} SCCR_{t-i}]$$

(j=4; SPR-futures)

$$SPRF; \quad SFAR_t = SEAS_{jt} + \sum_{i=0}^{19} [\beta_{jhi} FPSH_{t-i} + \beta_{jhi} FPSC_{t-i} + \beta_{jrhi} SFHR_{t-i} + \beta_{jrci} SFCR_{t-i}]$$

(j=5; APR-cash)

$$APRC; \quad SFAR_t = SEAS_{jt} + \sum_{i=0}^{17} [\beta_{jhi} CPH_{t-i} + \beta_{jci} CPC_{t-i} + \beta_{jrhi} ACHR_{t-i} + \beta_{jrci} ACCR_{t-i}]$$

(j=6; APR-futures)

$$APRF; \quad SFAR_t = SEAS_{jt} + \sum_{i=0}^{19} [\beta_{jhi} FPSH_{t-i} + \beta_{jhi} FPSC_{t-i} + \beta_{jrhi} AFHR_{t-i} + \beta_{jrci} AFCR_{t-i}]$$

where

$SFAR_t$ = actual sow farrowings, 100 head, 10 states, hog quarters.

CPH_t = real cash price of hogs (barrows and gilts); 7 markets, (\$/cwt).

CPC_t = real cash price of corn received, U.S., (\$/bu).

${}_{t+i}FPH_t$ = real futures price of hogs for period t+i in period t, (\$/cwt).

${}_{t+i}FPC_t$ = real futures price of corn for period t+i in period t, (\$/bu).

$FPSH_t = ({}_{t+1}FPH_t + {}_{t+2}FPH_t + {}_{t+3}FPH_t) / 3$

$FPSC_t = ({}_{t+1}FPC_t + {}_{t+2}FPC_t + {}_{t+3}FPC_t) / 3$.

Table 1. (Continued)

$WCPC_t = (.4\ CPC_t + .25\ CPC_{t-1} + .2\ CPC_{t-2} + .15\ CPC_{t-3})$

$WFPC_t = (.4_t FPC_t + .25_{t-1} FPC_{t-1} + .2_{t-2} FPC_{t-2} + .15_{t-3} FPC_{t-3})$

$SCHR_t = (CPH_t - CPH_{t-4})^2$

$SCCR_t = (WCPC_t - WCPC_{t-4})^2$

$SFHR_t = ({}_tFPH_t - FPSH_{t-4})^2$

$SFCR_t = (WFPC_t - FPSC_{t-4})^2$

$ACHR_t = SCHR_t$ if $CPH_t < CPH_{t-4}$
0 otherwise

$ACCR_t = SCCR_t$ if $WCPC_t > WCPC_{t-4}$
0 otherwise

$AFHR_t = SFHR_t$ if ${}_tFPH_t < FPSH_{t-4}$
0 otherwise

$AFCR_t = SFCR_t$ if $WFPC_t > FPSC_{t-4}$
0 otherwise

$SEAS_{jt} = \beta_{jconst} + \beta_{j1}D_1 + \beta_{j2}D_2 + \beta_{j3}D_3 + \beta_{j4}T$

β_{jconst} = estimated constant in the jth model

D_1 = dummy variable; December-February

D_2 = dummy variable; March-May

D_3 = dummy variable; June-August

T = time trend

Note: All prices are deflated by the index of prices received by farmers; (1910-14=100).

Table 2. Estimated[a] Dynamic Effects and Associated Statistics of Price Risk on Sow Farrowing Supply Models Using Cash Prices and Futures Prices from 1973-86.

	Models Using Cash Prices			Models Using Futures Prices		
Variable	CC (j=1) m=16	SPRC (j=3) m=17	APRC (j=5) m=17	CF (j=2) m=16	SPRF (j=4) m=19	APRF (j=6) m=19
Constant	4904.5	1034.7	7198.1	8218.6	-789.9	-2352.7
	(8.58)	(.17)*	(1.45)@	(9.17)	(-.154)*	(-.504)*
D_1	-310.8	-331.4	-347.7	-322.0	-330.2	-329.9
	(-8.24)	(-10.60)	(-12.7)	(-7.49)	(-10.15)	(-13.63)
D_2	234.3	188.0	167.1	208.9	144.6	140.6
	(6.23)	(5.97)	(6.17)	(4.93)	(3.84)	(5.47)
D_3	-24.7	-72.6	-93.4	-36.3	-73.6	-121.9
	(-.65)*	(-2.35)	(-3.19)	(-.861)*	(-2.08)	(-3.97)
T	-16.3	-26.9	-32.5	-43.8	-26.5	-30.9
	(-7.68)	(1.01)*	(-1.62)@	(-8.79)	(-1.21)*	(-2.87)
P^{hogs}	493.9	1101.2	702.4	461.5	916.4	1080.0
	[11.36]	[9.82]	[7.18]	[7.71]	[3.00]*	[1.96]*
P^{corn}	-11493.0	-9288.1	-16483.0	-12405.0	-2411.0	-1773.4
	[30.74]	[3.87]@	[10.16]	[23.76]	[4.33]@	[1.25]*
R^{hogs}		-30.0	-1.92		4.90	-378.1
		[7.27]	[11.47]		[1.99]*	[3.74]@
R^{corn}		-223800.0	-146770.0		-304110.0	-225770.0
		[1.39]*	[4.04]@		[4.88]@	[18.27]
joint significance of hog and corn risk		[4.85]	[7.76]		[7.33]	[15.37]
E_{hogs}	1.571	3.932	2.508	1.657	3.290	3.878
E_{corn}	-2.281	-1.843	-3.271	-2.720	-.529	-.389
$E_{risk/hog}$		-.037	-.0013		.0052	-.164
$E_{risk/corn}$		-.551	-.229		-.515	-.299
Durbin-Watson	1.296	1.897	2.541	1.144	2.571	2.832
$\bar{R}^2$	.909	.948	.961	.885	.966	.970
d.f.	29	22	22	29	20	20

[a] All models (j=1,...6) were estimated with a second order polynomial lag of order m on all lagged variables. $\bar{R}^2$ and d.f. signify the adjusted coefficient of determination and model degrees of freedom, respectively. Numbers in parentheses and brackets signify t-ratios and F-ratios, respectively. The * and @ symbols designate insignificance at .05 and .01 levels, respectively.

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