DEPARTMENT OF AGRICULTURAL ECONOMICS

Hedging Cull Sows Using the Lean Hog Futures Market

Annual income from cull sows represents a relatively small percentage (3 to 5 percent) of total gross income generated in a farrow-to-finish operation. Because cull sows represent such a small portion of total income, managing price risk associated with cull sows is often overlooked. However, as profit margins tighten and swine operations increase in size, the benefit of managing price risk associated with cull sows increases. In addition, sow processors face considerable sow price risk and may benefit from using futures markets to reduce sow procurement price risk.

Managing price risk for agricultural commodities is typically done through the use of forward contracts or hedging in the futures and options markets. The problem for a commodity such as cull sows is the lack of a futures market specifically for cull sows. The Chicago Mercantile Exchange (CME) has a Lean Hog futures contract. The Lean Hog futures contract is based on pigs that are 51 to 52 percent lean, have backfat of 0.80 to 0.99 inches, and with a base carcass weight of 170 to 191 pounds. The contract size is based on 40,000 pounds of carcass, which equates to approximately 54,000 pounds of liveweight (74 percent yield). These specifications are based on the carcass of a typical market hog and not the carcass of cull sows. Because there is not a futures market designed specifically for cull sows, in order to hedge cull sow prices using the futures or options market, producers need to cross hedge. A cross hedge is defined as hedging the price of one commodity (e.g. cull sows) using the futures market of another commodity (e.g. market hogs).

Cross hedging is routinely done for a number of agricultural commodities. For example, grain sorghum (milo) is hedged using the corn futures market and cull cows can be cross hedged using the boneless beef 90 percent lean futures contract (for more information and examples pertaining to cross hedging other commodities see K-State Research and Extension bulletin *Cross Hedging Agricultural Commodities*, MF-1003). When cross hedging a commodity, physical delivery cannot take place because the commodity being hedged does not meet contract specifications of the futures market in which the hedge is placed. However, this is not an issue when using the Lean Hog futures contract as this contract is cash settled, thus, no deliveries ever occur.

In order to successfully cross hedge a commodity it is critical that the price of the commodity being hedged and the price of the futures contract used are closely related and follow one another in a predictable manner. If the two prices follow each other in a predictable manner, hedged price risk will be less than unhedged price risk. Hedged price risk refers to the price that is received when hedging relative to what was expected (this is also commonly referred to as basis risk) and unhedged price risk refers to general price level variability. If the price of the commodity being hedged and the price of the futures contract used do not follow each other in a predictable manner, cross hedging will not be successful as hedged price risk may be greater

than unhedged price risk. In addition to the two prices being correlated, it is important that large enough quantities are being traded to meet cross hedged futures contract size specifications. In other words, producers need to be selling, or processors need to be buying, enough sows at a time to coincide with the hedged quantity.

The objectives of this publication are to present information pertaining to cross hedging cull sows and to recommend strategies or examples of cross hedging sows. The information and application of this information pertain to both producers hedging their selling price and processors hedging their purchase price. Additionally, the information can be applied to marketing strategies involving either the futures or options markets.

Cross Hedging Issues

When conducting research to examine the feasibility of cross hedging for a particular commodity, several issues must be addressed. First, the futures market in which to cross hedge the commodity must be identified. Second, the size of the futures position to take needs to be determined. Third, the cross hedge relationship should be examined to see if it is sensitive to the time of the year. Finally, riskiness of the cross hedging relationship needs to be considered.

The futures contract to use when cross hedging is the one with a price pattern that is similar to the cash commodity being hedged. For some commodities this may not be obvious (e.g. alfalfa). However, for cull sows the relevant futures market to use for cross hedging is the Lean Hogs futures contract. Once the appropriate futures market has been defined, the size of a futures position to take to cover a particular cash position needs to be determined. For example, when hedging market hogs using Lean Hog futures, the general recommendation is to use one 40,000-pound contract for each 40,000 pounds of carcass, or 54,000 pounds of liveweight, to be hedged. However, when cross hedging cull sows in Lean Hog futures, this one-to-one relationship may, or may not, be the optimal futures-to-cash hedge ratio. It may be less risky to take a larger or smaller position in the futures market than the cash market position to be hedged.

Determining the Hedge Ratio

Determining the size of the futures position to take requires calculating a hedge ratio. This hedge ratio is found by estimating the relationship between the futures price and the cash price of the commodity being hedged according to Equation 1:

$$\textit{Expected cash price} = \beta_0 + \beta_1 \textit{ (Futures price)} \qquad (1)$$

where β_0 is the intercept or expected basis and β_1 is the hedge ratio. This equation identifies the relationship between the futures price and the cash price, based on historical prices, and allows the hedger to determine the cash price that could be expected by cross hedging.

The hedge ratio (β_1) is the futures contract quantity divided by the cash market quantity being hedged. It is an estimate of the relative price change between the futures market and the cash market. A hedge ratio of 1.0 implies a one-to-one relationship between the prices—for every $1 per unit change in the futures price, the cash price of the commodity being hedged changes by $1 per unit in the same direction. A hedge ratio greater than 1.0 implies the cash price changes by more than $1 per unit for every $1 per unit change in the futures price. Similarly, a hedge ratio less than 1.0 implies the cash price changes by less than $1 per unit for every $1 per unit change in the futures price. Because the Lean Hog futures contract is quoted on a lean value basis (i.e., carcass weight) and cull sow prices are quoted on a liveweight basis, the hedge ratio will not be one even if liveweight prices of market hogs and sows are perfectly correlated. For market hogs, if a one-to-one relationship existed between the cash price and the Lean Hog futures price, we would expect a hedge ratio of 0.74 as this is the factor used to convert carcass price to liveweight price. Therefore, when cross hedging cull sows using the Lean Hog futures market, a hedge ratio of 0.74 indicates a one-to-one relationship between futures and cash prices when both are on a liveweight basis.

The hedge ratio definition, i.e., futures contract quantity divided by cash market quantity, can be rearranged as Equation 2:

$$\textit{Cash quantity hedged} = \frac{\textit{Futures contract quantity}}{\beta_1} \qquad (2)$$

where *Futures contract quantity* is the weight amount per futures contract and *Cash quantity hedged* is the effective weight of cash commodity being hedged per futures contract. For cull sows, Equation 2 can be used

to calculate an estimate of the liveweight pounds of cull sows being hedged per Lean Hog futures contract (40,000 carcass pounds).

The hedge ratio (β_1) and expected basis (β_0) will vary by commodity, which means Equation 1 needs to be estimated for any commodity considered for cross hedging (in this case, cull sows). Additionally, any seasonality that exists between the Lean Hog futures price and the cull sow price implies the hedge ratio and expected basis may vary seasonally, thus, Equation 1 also should be estimated for different futures contract months. Similarly, the hedge ratio and expected basis may vary by location. Therefore, Equation 1 should be estimated for different cash cull sow markets.

Cross Hedging Risk

Several statistics can be used to help measure the risk of a proposed cross hedge. When estimating Equation 1 a measure known as R^2 is obtained, which is the proportion of total variability in the dependent variable (cash price) explained by the independent variable (futures price). When cross hedging cull sows, the dependent variable is cull sow prices and the independent variable is the Lean Hog futures price. An R^2 value of 0.75 means that 75 percent of the variability in cull sow prices is explained by variability in the Lean Hog futures price. The higher the R^2, the stronger the relationship between the two prices and the less risk the cross hedge will involve. An R^2 of 1.0 implies a perfect correlation between the dependent and independent variables.

Another statistic used to measure cross hedging risk is the Root Mean Squared Error (RMSE). The RMSE is a measure of the variation of the expected cash price around the actual cash price. In the literature relating to production, a measure of variation around an expected value is the standard deviation. It should be noted when forecasting, as is the case here, these two measures are equal. The more dispersed cash prices are from their expected prices, the greater the RMSE and the poorer the fit of the regression equation. An RMSE of zero implies a perfect correlation between the dependent and independent variables. As the RMSE increases, the risk associated with cross hedging also increases. An RMSE value of three can be interpreted to mean that 68 percent of the time the actual cross hedged cash price would be expected to lie within plus or minus $3 per hundredweight of the expected cash price.

Typically, as the R^2 value increases, the RMSE value decreases. Both of these measures of risk are computer generated. Thus, it is recommended that those considering cross hedging cull sows (or any other commodity) use some type of computer software to help estimate the associated expected risks.

Data Used

Weekly average USDA price data from July 1986 through December 1997 were used for all analyses. Cull sow cash price data were gathered from Omaha, Neb. for three different weight categories; 300 to 400, 400 to 500, and 500 to 600 pounds. Prices also were gathered from St. Joseph, Mo. for the 400- to 500-pound weight category. Lean Hog futures prices used were for the nearby contract. Prior to the February 1997 contract, futures prices were for the Live Hog futures contract and were converted to Lean Hog prices by dividing by a factor of 0.74. Futures contracts were rolled to the next contract in the week a contract expired. For example, if the February contract expired in the third week of the month, the nearby contract in the second week of February was the February contract and the nearby in the third week of February was the April contract.

Results—Expected Basis and Hedge Ratios

Figure 1 shows the Omaha weekly seasonal price index for 400- to 500-pound sows and 230- to 240-pound barrow and gilts (B&G). The two price indices follow similar patterns at some times of the year, but they diverge at other times. For example, market hog prices generally decrease in February and March before starting to increase in mid-April. Whereas, sow prices increase during the month of February and remain at relatively strong levels though April. Similarly, the two price indices diverge in July and November. Because the seasonal price patterns differ at certain times of the year, the need to estimate Equation 1 for the different futures contract months is reinforced. It also is expected the correlation between cull sow prices and Lean Hog futures prices (i.e., R^2) will vary for the different contract months because of these seasonal patterns.

Figure 2 shows the 1993 through 1997 weekly average price for 400- to 500- and 500- to 600-pound sows in Omaha and the price for 400- to 500-pound sows at St. Joseph. Heavier sows bring a premium relative to lighter-weight sows, but the difference

varies seasonally. For example, the spread between the two prices is relatively wide in February through April and again in September and October. The price of 400- to 500-pound sows at Omaha and St. Joseph are similar for much of the year, but they do diverge at some times. Because of these weight and location price differences for certain times of the year, Equation 1 also needs to be estimated for each weight category and location.

The results of estimating Equation 1 by futures contract month for the different weight cull sows and the different locations are presented in Table 1. Across sow weights, locations, and futures contracts, the hedge ratio ranges from 0.661 to 1.049 and the intercept (expected basis) ranges from –27.64 to 4.06 indicating sizeable differences exist in optimal hedge ratios. The largest differences appear to be seasonal (i.e., variation across futures contracts) with smaller differences across sow weights. However, there are some weight by seasonal differences hedgers need to be aware of. For example, the hedge ratio and intercept values are very similar across sow weights for the June contract, but there are fairly large differences in these values for the February contract. This suggests that in addition to seasonality in prices, the differences between heavy and lightweight sow prices also varies seasonally.

An example of cross hedging 400- to 500-pound cull sows would work as follows: A swine producer in the Omaha market area wants to reduce price risk by hedging the selling price of cull sows using the June CME Lean Hog futures contract. Given a June contract futures price of $72.47 per hundredweight in April, referring to Table 1, the hedge ratio and expected basis (intercept) for 400- to 500-pound sows in Omaha are 0.737 and –13.18 respectively. Using Equation 1, the expected cash price of the cull sows would be $40.23 per hundredweight (–13.18 + 0.737 × $72.47 per hundred weight. This hedge ratio of 0.737 indicates that the price of Omaha 400- to 500-pound

Figure 1. Seasonal price index for 400- to 500-pound sows and 230- to 240-pound barrows and gilts, Omaha, Neb., 1993 to 1997.

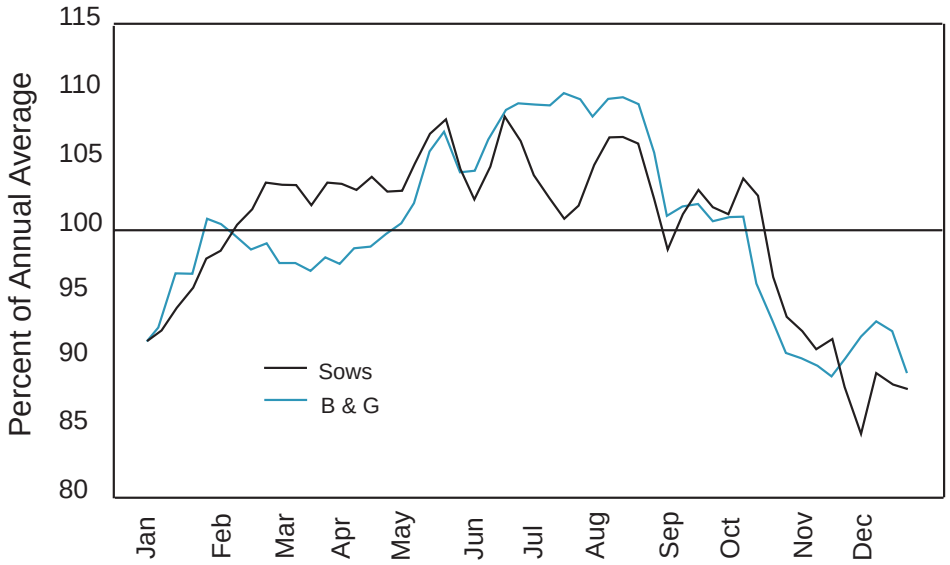
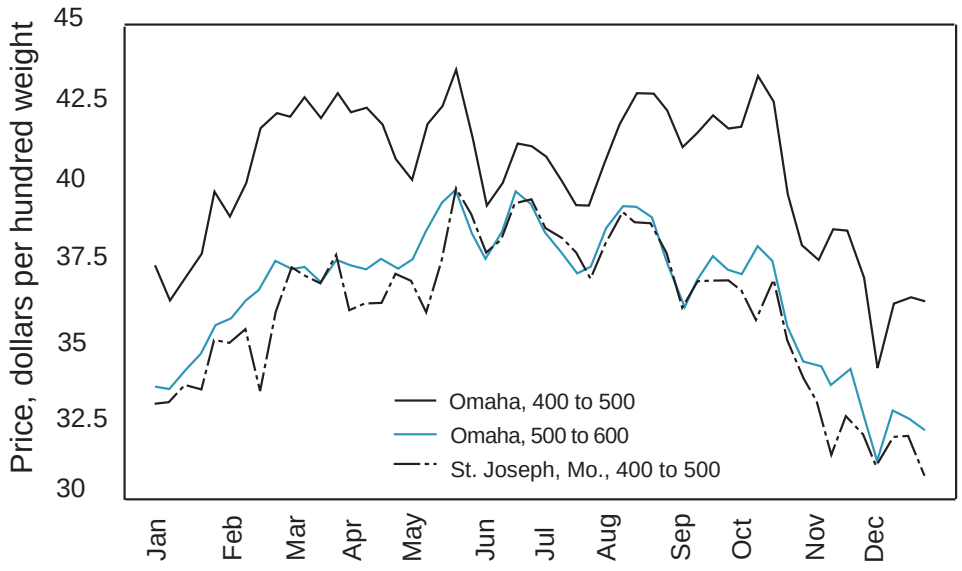


Figure 2. Average price for 400 to 500 and 500- to 600-pound cull sows in Omaha, Neb. and 400- to 500-pound sows in St. Joseph, Mo., 1993 to 1997.



sows historically have followed an approximate one-to-one relationship with the Lean Hog futures price on a liveweight basis. However, they are $13.18 less than the futures price. If on the other hand, this producer was considering hedging the selling price of 500- to 600-pound sows in January using the February contract his expected price, given a futures price of $72.47 per hundred weight, would be $48.38 (–27.64 + 1.049 × $72.47 per hundred weight). In this case, even though the expected basis is over $14 lower, the expected cash price is $8.15 higher because of the larger hedge ratio.

A producer interested in using put options to hedge the selling price of their cull sows would use the information from Table 1 in the same manner. However, instead of multiplying the hedge ratio times the Lean Hog futures price, they would multiply the hedge ratio times the put option strike price being considered less the option premium. In this case, the expected cash price resulting from Equation 1 would represent a minimum expected price as opposed to a flat price. For example, consider a producer wanting to hedge 400- to 500-pound sows using the June CME Lean Hog put

Table 1. Cross Hedge Estimates for Hedging Cull Sows at Omaha and St. Joseph in Lean Hog Futures, July 1986 through December 1997.

Location-weight/ Lean hog futures contract month	*Hedge ratio (β_1)*	*Intercept (β_o)*	*RMSE*	*R^2*	*Cull sow lbs. hedged per contract*	*Estimated number of sows*
Omaha, US 1–2, 300 to 400 lb. sows						
April	0.661	– 4.06	2.95	0.70	60,528	173
June	0.727	–12.67	3.09	0.82	54,994	157
July	0.848	–20.06	2.81	0.86	47,147	135
August	0.856	–19.39	3.01	0.86	46,709	133
October	0.768	–8.92	3.73	0.76	52,066	149
December	0.840	–17.15	2.75	0.87	47,627	136
Omaha, US 1–2, 400 to 500 lb. sows						
February	0.892	–20.71	2.68	0.83	44,823	100
April	0.713	–6.98	2.99	0.72	56,112	125
June	0.737	–13.18	2.99	0.84	54,283	121
July	0.831	–18.96	2.74	0.86	48,137	107
August	0.868	–20.23	2.78	0.88	46,098	102
October	0.796	–10.48	3.43	0.80	50,267	112
December	0.877	–19.27	2.64	0.89	45,628	101
Omaha, US 1–3, 500 to 600 lb. sows						
February	1.049	–27.64	8.43	0.82	38,134	69
April	0.731	–4.57	3.24	0.70	54,697	99
June	0.739	–11.87	3.01	0.83	54,136	98
July	0.880	–21.79	3.17	0.84	45,432	83
August	0.917	–22.24	2.56	0.91	43,625	79
October	0.909	–14.02	3.5	0.83	44,019	80
December	0.985	–23.22	3.42	0.86	40,601	74
St. Joseph, US 1–2, 400 to 500 lb. sows						
February	0.866	–19.60	2.8	0.81	46,174	103
April	0.773	–11.45	3.44	0.70	51,714	115
June	0.776	–16.45	3.5	0.80	51,522	114
July	0.864	–21.30	2.51	0.89	46,294	103
August	0.865	–20.20	2.9	0.87	46,251	103
October	0.798	–11.06	3.67	0.78	50,112	111
December	0.857	–18.58	2.87	0.87	46,692	104

options. Given a June put option strike price of $72 with a premium of $2.35 in April, using Equation 1, the minimum expected cash price of the cull sows would be $38.15 per hundredweight (–13.18 + 0.737 × ($72.00–$2.35) per hundred weight). A processor wanting to use call options to hedge the purchase price of sows would use Equation 1 in the same manner except the option premium would be added to the strike price rather than subtracted.

Table 1 also shows the amount of pounds of cull sows (liveweight basis) and the number of sows (assuming the sows' average weight is the midpoint of the range) that would be hedged with one Lean Hog futures contract. In the first example above, one June Lean Hog futures contract would effectively hedge the price of 121 sows in the 400- to 500-pound range. However, in the second example, one February Lean Hog futures contract would effectively hedge 69 sows. If a producer, or processor, wants to maintain a 100 percent hedged position it is important that they remember that as the hedge ratio changes, the amount of pounds hedged per futures contract also changes.

Hedging risk (basis plus hedge ratio) can be evaluated by the R^2 and RMSE values reported in the Table 1. The R^2 values generally fall between 0.80 and 0.90 indicating there is a relatively strong correlation between cull sow prices and the Lean Hog futures price. Regardless of sow weight or location, the R^2 for the April contract is the lowest indicating more cross hedging risk with this contract relative to the other contracts. This is due to sow prices increasing relative to market hog prices during this time period (Figure 1). Similarly, R^2 values are highest for the July, August, and December contracts indicating cull sows and Lean Hog futures prices have a stronger correlation at these times of the year relative to other time periods. On average, R^2 values were higher for the heavier sows relative to the lighter weight sows. Omaha values were higher compared to St. Joseph values, however the differences were small.

Values of the RMSE generally fall in the range of 2.5 and 3.5 indicating that one would expect the actual cash price to fall with plus or minus about $3 per hundredweight of the expected price 68 percent of the time. Continuing with the example given above with an expected cash price of $40.23, the RMSE for the June contract is 2.99, which would indicate a hedger would expect cash prices to fall between 37.24 and 43.22 [40.23 ± 2.99] 68 percent of the time. This information provides the producer or processor an indication as to the risk involved with the cross hedge. In all cases, RMSE values for the October contract were higher than the other months and the December and February contracts generally had low RMSE values. As with the R^2 values, RMSE values indicate there is more risk associated with cross hedging sows in St. Joseph relative to Omaha and heavy sows compared to lighter weight sows, but the differences are small.

Regardless of which risk measure is considered, there is more cross hedging risk for culls sows seasonally than there is across weight category or location. This indicates, with regards to hedged price risk, producers or processors wanting to cross hedge sows should be more concerned with the time of the year than the weight of the sows or the cash market category.

Recommendations for Cross Hedging Cull Sows

The cross hedging data presented in Table 1 are for specific locations and may not be representative of other regions. Different locations may have unique hedge ratios and basis behavior. However, even if a producer is not marketing his cull sows in Omaha or St. Joseph, this information can be useful for cross hedging purposes if their market has a strong relationship with either of these other markets. For example, if a producer marketing cull sows consistently receives $2 per hundred weight below the Omaha cull sow price, they can adjust the expected basis (intercept) by this amount and use Equation 1 to estimate an expected cash price. Alternatively, if sufficient historical cash price data is available, individuals could estimate the optimal hedge ratios and price relationships for their specific cash market.

Cross hedging will not eliminate price risk entirely because basis risk still exists when hedging. However, basis fluctuations can be either beneficial or detrimental to the hedger depending on whether a short or long hedge has been placed and on the direction of basis change. Before deciding to cross hedge, producers or processors should consider the risk they expect to face by cross hedging and compare this to the price risk they face if they do not hedge.

The information in this publication should help determine the equivalent price that could be hedged for cull sows, the size of position to take for a given number of sows, and the associated risk. This publica-

tion does not address when a hedge should be placed. The decisions of if and when to hedge must be based on analyses of costs of production, desired returns, degree of risk aversion, current fundamental information, and future expectations. Until this information has been gathered and analyzed, a producer should not be concerned with what size of position to take in the futures market. After gathering this information, it may be determined that only a percentage of expected sales (or purchases) should be hedged. Since futures contracts have fixed quantity specifications (e.g., 40,000 pounds), it is unlikely that hedges can be placed to cover the exact quantities of sows a producer (processor) desires to hedge and either over- or under-hedging typically occurs. To determine which way to hedge, the relative risks and expected payoffs from taking a smaller or larger futures position must be weighed.

After the cross hedging transaction has been completed, the hedger should evaluate how the hedge performed. The first aspect of the hedge to evaluate is how close the actual price received (paid) was to the expected price, after adjusting for any gains or losses in the futures market and any brokerage fees. The evaluation of the performance of the hedge should be done independently of the evaluation of the marketing strategy. Deciding whether it was wise to have taken a market position at the time it was taken should be evaluated with the strategy and not the performance of the hedge. In other words, a hedge is considered successful if the actual price received is approximately equal to the expected cash price; whereas, a marketing strategy is considered successful if it met the objectives of the market plan.

References

Graff, J., T. Schroeder, R. Jones, and K. Dhuyvetter. *Cross Hedging Agricultural Commodities.* K-State Research and Extension Bull. MF-1003 (Sept. 1997).

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Kansas State University Agricultural Experiment Station and Cooperative Extension Service

MF-2338 June 1998

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File code: Farm Management 3-2