Formula-Derived versus Observed Market Prices:
An Application for Segregated Early Weaned Pigs

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A formula (the "K-State formula") for deriving the price of segregated early weaned (SEW) pigs using corn, soybean meal, and market hog prices was estimated based on equating return on investment for the different phases of swine production – farrow, nursery, and finish. USDA reported SEW pig prices were compared with prices derived from the K-State formula and several other common formulas. Based on root mean squared error and mean absolute error accuracy measures, the K-State formula did a better job of predicting spot-market prices than the other formulas. In terms of the K-State formula accurately predicting spot market prices, producers appear to form price expectations based on futures plus expected basis more so than simply futures prices or current cash prices. However, the manner in which the formula is used (i.e., method of choosing price expectations) will depend on the risk attitudes of the buyer and seller as well as the nature of their business relationship. Developing pricing formulas based on the framework outlined here (equal returns on investment) has merit for establishing prices in the absence of publicly reported information, however, it is important that users of the formula understand the conceptual framework of how and why it was developed.

Key Words: SEW prices, Formula prices, Marketing

Introduction

Agriculture is moving away from traditional commodity markets to more segmented specialized markets (e.g., non-genetically modified grains, high lysine corn, and organic produced beef). Such nontraditional markets are often thin and public market information is scarce. In other cases, market information may be plentiful but it is hard to generalize or summarize prices because of numerous variables (e.g., current livestock price reports). Thus, the question arises, in the absence of useable publicly reported market information, how are prices or values of exchange established?

In the absence of publicly reported price data, buyers and sellers could collect their own information and negotiate prices based on that information. However, because costs of collecting and analyzing information and negotiating individual transaction prices are high relative to the value of the underlying commodity, buyers and sellers often revert to some type of formula price. Another motivation for using pricing formulas is the increased levels of contracting in agriculture. While contracting does not require a pricing formula, many contracts do rely on some type of formula pricing mechanism. The lack of useable public information and increased contracting will likely lead to further increases in the use of formula pricing in agriculture in the future.

Although formula pricing methods vary, the use of formula pricing is common in agriculture (e.g., cash grain prices based on futures, fed cattle prices based on market average price, slaughter hog prices based on spot market quotes, land crop share and cash rents based on land values and production costs). The widespread use of formula pricing arrangements in agriculture suggests this is an acceptable method of establishing prices/values. Even though formula pricing is common, several issues arise pertaining to formula-derived prices: 1) Can pricing formulas be developed that are "consistent" with negotiated spot-market prices? 2) How do different pricing formulas compare with regards to their ability to predict spot-market prices? and 3) How sensitive are formula prices to the methods in which they are used?

In many cases, even though pricing formulas are used, publicly reported market information exists. These publicly reported prices can be used to adjust formulas to help keep formula prices "in line" with negotiated market prices (i.e., cash or spot prices). Furthermore, the pricing formulas may actually be tied to the publicly reported prices (i.e., formula price equals reported cash price +/- adjustments). However, what happens in a market when no publicly reported prices exist? The swine industry provides a good case study of how a specific market responded in the absence of publicly reported price information.

The swine industry has undergone many structural and technological changes in the last decade. The practice of separating farrow-to-finish production into three distinct phases at multiple locations was one such change. The practice of weaning pigs at an early age was also widely adopted. Segregated early weaning (SEW) was developed because it produces healthier, more efficient pigs and helps maximize genetic potential of breeding stock.[1] As SEW practices were adopted, a new problem emerged — how to value early weaned pigs? By definition, SEW pigs are kept separate from other pigs so marketing them through traditional auction barns where buyers and sellers meet to "discover a price" was not a viable option. Thus, a private treaty market for SEW pigs evolved that did not have publicly reported prices.

Because no market price quote existed for SEW pigs and negotiating price for each transaction was costly and time consuming, buyers and sellers looked for pricing formulas to place a value on SEW pigs. Numerous formulas were developed varying from a flat price per head to more complex formulas where price was a function of market hog, corn, and soybean meal prices. In the fall of 1997 the U.S. Department of Agriculture (USDA) Agricultural Marketing Service (AMS) began collecting and publishing a weekly price report for direct sales of weaned pigs (NW_LS255 report). The report attempts to exclude contract sales and summarize cash market trades only. Now that prices are publicly reported, spot-market prices can be compared to formula-derived prices. Keep in mind that formulas for valuing SEW pigs were developed and used extensively in the industry prior to any reported price information being available.

The objective of this paper is to explain what happens in a commodity market when publicly reported prices are not available. Specifically, this paper examines pricing of segregated early weaned

[1] Segregated early weaned (SEW) pigs are typically weaned at 14-18 days of age and weigh approximately 9-11 pounds. Segregated early weaning leads to "high health status" pigs because the pigs are weaned while they still have immunity to infectious agents carried by the sows (Clark).

(SEW) pigs in the absence of market information. A methodology for valuing SEW pigs using a cost-return formula-based framework is developed and formula-derived prices are compared with spot-market prices to determine how well formulas reflect market conditions. A second objective is to test the efficiency of selected formula pricing methods. Finally, this paper shares what has been learned from six years of working with producers who have established formula-based approaches for valuing SEW pigs.

Formulas for Valuing SEW Pigs

Numerous methods could be used to determine the value of pigs in the absence of a relevant market price quote. Several formulas have been developed for valuing SEW pigs (DiPietre, Dahlgran, and Tubbs; DiPietre and Tubbs (1994a); DiPietre and Tubbs (1994b); Koehler, Lazarus, and Buhr; and Zering). These formulas varied from valuing pigs based on cost of production to expected profitability. However, none of these formulas explicitly considered costs at all stages of production (farrow-to-wean, nursery, and finish) typical of multiple-site production. In a competitive market, on average we expect returns to be comparable across production stages and thus market-observed prices should reflect this.

Dhuyvetter estimated a formula for valuing SEW pigs by equalizing return on investment for each of the production phases (farrow, nursery, and finish) given prices for grain sorghum, soybean meal, and market hogs. He developed a formula, based on relative costs of production for the different phases, where the price for pigs is a function of major determinants of profitability (market hog price and feed prices). An advantage of this formula is that it allows risk to be shared, but a disadvantage is the difficulty in determining the criteria and costs of each phase to use in deriving the formula. Returns should not be shared equally if the different phases of production have significantly different risks. However, Dhuyvetter did not explicitly account for relative risks in the different production phases in his formula because of insufficient data pertaining to risk differences.

Meyer and Lazarus, in an industry publication, discuss four basic methods of establishing weaned pig prices: 1) flat price; 2) 52% times lean hog futures price ($/cwt on a carcass-weight basis); 3) lean hog futures price ($/cwt on a live-weight basis) less $15 nursery allowance; and 4) equal return on investment. A flat price is simple and popular in the industry, with the most common price being $32/head. With a flat price for SEW pigs, the buyer (i.e., hog finisher) assumes all market hog risk and the majority of feed price risk. Using a percent of the futures price as a formula for establishing prices puts part of the market hog price risk on the seller (i.e., farrower) but the majority of the feed price risk remains with the buyer. Meyer and Lazarus noted that a common practice for valuing SEW pigs is to subtract a nursery allowance from a published feeder pig (40-50 pound) price. However, because feeder pig auctions are becoming thin markets they suggested using the lean hog futures market on a live-weight basis ($/cwt) as a proxy for feeder pig prices ($/head).[2] They contended this is appropriate because the futures market is a liquid market. However, SEW formulas based on historical relationships of feeder pig prices to market hog prices may not be appropriate because SEW pigs are of higher quality. Schroeder, Jones, and Nichols found that feeder pig health, pig weight, lot size, and uniformity had significant impacts on feeder pig prices received at auctions. Therefore, due to differences in health status, weight, and performance potential of SEW pigs compared to the more

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[2] This implies a 1:1 relationship between market hog prices ($/cwt) and feeder pig prices ($/head). Based on weekly data from Iowa feeder pig auctions for the 1975-1985 time period, Lawrence and Schmidt estimated this relationship to be 0.945 (i.e., feeder pig price, $/head = 0.945 x market hog price, $/cwt).

traditional 40-50 pound feeder pig, previously developed formulas for feeder pigs may not be suitable for pricing SEW pigs. With reference to a formula based on equal returns on investment, Meyer and Lazarus stated that "Many view this as the gold standard in weaned pig pricing and most consider it as the most intuitively fair pricing method." (p. 12). However, they indicated that this method is complex and is highly dependent on cost and production assumptions made.

Now that over three years of publicly reported prices for SEW pigs are available, formula-derived prices can be compared to market-observed prices (i.e., spot-market prices). Thus, prices derived from a formula based on equal returns on investment can be compared relative to other formulas to determine if this really is the "gold standard" of formulas.

Data and Methods

Projected cost-return budgets for swine farrow-to-wean, nursery, and finishing phases (Dhuyvetter and Tokach; 2000a, 2000b, and 2000c) were used as the foundation for developing a pricing formula based on equal return on investment.[3] These budgets were developed to reflect full economic costs of a modern commercial-sized operation. The price of a 10-pound weaned pig represents the output for the farrowing phase and an input for the nursery phase. Likewise, the price of a 55-pound feeder pig represents the output from the nursery and an input for the finishing phase. Given all costs and income for the different production phases, weaned and feeder pig prices can be solved for that equate return on investment for all three production phases.

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[3] Formulas estimated previously by Dhuyvetter were re-estimated because some of the production and cost parameters in the budgets have changed slightly over time. For example, feeder pigs and market hogs weighed 60 and 250 pounds, respectively, in the earlier budgets but these values have been changed to 55 and 260 pounds to reflect current industry practices. Also, pig diets were based on using corn rather than grain sorghum.

Weaned and feeder pig prices that equate return on investment were solved for using weekly market hog, corn, and soybean meal prices from January 1990 through June 2000 (546 weeks).[4] All other variables were held constant over the 546 simulations because market hog, corn, and soybean meal prices are the major profitability determinants varying the most over time.[5] Weaned pig prices were solved for over time to generate observations that could be summarized using the following equation

$$(1) \qquad WP_i = b_0 + b_1 CN_i + b_2 CN_i^2 + b_3 SBM_i + b_4 SBM_i^2 + b_5 MH_i + b_6 MH_i^2 \;,$$

where WP is the weaned pig price calculated that equates return on investment for all three production phases; CN, SBM, and MH are historical observed corn, soybean meal, and market hog prices, respectively, and i is an index for week (i = 1, 2, ... 546). The results of estimating equation 1, hereafter referred to as the "K-State formula," with ordinary least squares are presented in Table 1. Weaned pig prices decrease at a decreasing rate as feed prices increase and increase at a decreasing rate as market hog prices increase. The R^2 value of 0.999 indicates that the quadratic functional form of equation 1 is a good approximation of the true functional form.

The K-State formula (equation 1) was estimated using actual prices. However, to value weaned pigs in real-time with the formula requires price expectations. Tomek suggested that publicly available price forecasts cannot outperform the futures market forecast supporting the use of futures

[4] Market hog prices were from Iowa-Southern Minnesota, corn prices were Central Illinois, and soybean meal prices were from Decatur, Illinois. A relatively long historical series of actual prices was used to represent price levels and combinations of inputs that might be observed in the future.

[5] Using this same methodology, other variables of interest could easily be added if desired. For example, if it were determined that replacement gilt price variability is an important factor, the simulations could allow that variable to vary as well.

prices for price expectations. Further, numerous studies have found that producers use the futures market in forming price expectations (e.g., Eales et al.; Gardner; Kenyon; Schroeder et al.). Kastens, Jones, and Schroeder concluded that a futures price plus historical basis forecast method was the most accurate among several competing forecasting methods for several commodities. Thus, equation 1 "inputs" (i.e., corn, soybean meal, and market hog prices) are based on deferred futures prices plus expected basis.[6]

In addition to the K-State formula, the following three formulas as outlined by Meyers and Lazarus were examined for comparison purposes

$$\text{(2)} \quad Weaned\ pig\ price = \$32 \ ,$$

$$\text{(3)} \quad Weaned\ pig\ price = Lean\ hog\ price_{CW} \times 52\% \ ,$$

$$\text{(4)} \quad Weaned\ pig\ price = Lean\ hog\ price_{LW} - \$15 \ ,$$

where *Weaned pig price* is the formula-derived price, $Lean\ hog\ price_{CW}$ is the lean hog futures price on a carcass weight basis, and $Lean\ hog\ price_{LW}$ is the lean hog futures price on a live weight basis. Carcass weight prices were converted to live weight prices using a conversion factor of 0.74.

Formula-derived prices are compared with observed spot-market prices to determine the relationship between these two price series. Spot-market prices for 10-pound weaned pig prices are from USDA report NW_LS255 from November 7, 1997 through June 1, 2000 (187 weeks). Formula-derived prices (i.e., equations 1-4) are compared to USDA reported prices by examining

[6] Alternative methods for valuing inputs in the K-State formula were examined to determine the sensitivity of the relationship between formula-derived and market prices. Alternative values were: deferred futures (no basis adjustment), naive (expected price = current cash price), and perfect foresight (expected price = actual price).

summary statistics, root mean squared error (RMSE), and mean absolute error (MAE). Additionally, efficiency of the various pricing formulas is examined by testing for bias and relative accuracy. Bias is tested by regressing the USDA reported price on the formula price and a joint test is used to test the null hypothesis, H_0: $b_0 = 0$, and $b_1 = 1$. If the null hypothesis is rejected based on an F-test, the forecast is biased (Figlewski and Wachtel). To statistically test the relative accuracy of the alternative formulas at predicting spot-market prices, the AGS test is used (for a detailed explanation of the AGS test see Brandt and Bessler or Bradshaw and Orden).

Results

Figure 1 shows the K-State formula-derived prices for 10-pound weaned pig prices and the USDA market reported prices from November 1997 through May 2000. The two prices move together (correlation of 0.826) indicating the K-State formula "predicts" market price patterns reasonably well. Formula-derived prices tend to be higher than spot-market prices during low-priced markets and vice versa during times with high prices. Thus, the formula smooths prices over time as expected given that the formula uses deferred futures prices.

In addition to the K-State formula, equations 2, 3, and 4 were used to derive weaned pig prices to compare with USDA reported prices. Table 2 reports the summary statistics for each series along with the RMSE and MAE for each of the formulas. The results of testing for bias and relative forecast accuracy (AGS test) are also given in Table 2. The price of weaned pigs, as reported by USDA, averaged \$29.31 per head and ranged from \$14.66 to \$40.93. The formula that provided the closest average price to the USDA-reported average was 52% of the lean hog futures (equation 3) — average of \$28.73 versus \$29.31. However, this formula resulted in a considerably higher minimum and lower maximum price indicating it smooths prices considerably relative to the spot market (even more so than the K-State formula). The null hypothesis of unbiased prices was rejected for all formulas indicating formula-derived prices were biased relative to the USDA spot market price.[7]

When comparing the different price series using the RMSE and MAE accuracy measures, the K-State formula was the most accurate formula. Not surprisingly, the flat price formula was the least accurate in terms of accurately predicting spot-market prices. The AGS test provides a way to determine if the K-State formula was statistically more accurate in terms of predicting spot-market prices relative to the alternative formulas. The results of the AGS test indicate that the K-State formula was significantly better than each of the other formulas.

The RMSE and MAE values reported in Table 2 are out-of-sample in the sense that the formulas were developed in the absence of any weaned pigs prices. As an additional sensitivity test, the parameter values in equations 2, 3, and 4 were optimized in-sample by minimizing RMSE to determine what impact this had. The optimal in-sample parameter values (original values) are $29.31 ($32), 53.4% (52%), and $11.59 ($15) for equations 2, 3, and 4, respectively. As expected, these in-sample modifications resulted in average prices that were close to the USDA-reported mean and improvements in the accuracy measures. The RMSE and MAE from the K-State formula (out-of-sample) were still lower than those from these in-sample formulas, however the AGS test could not be rejected in this case (results not shown).

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[7] Prices derived from the K-State formula (and other formulas) may have been found to be biased due to the particular time period considered. Or, it may be that the budgets behind the K-State formula do not accurately reflect industry averages. For example, if prices from the K-State formula are biased upwards, it may be that industry costs in the farrowing (nursery/finish) phase are lower (higher) than what is represented in the K-State budgets. Another explanation could be due to relative risk differences between the production phases which have not been accounted for here.

The prices and accuracy measures reported in Table 2 for the K-State formula were based on futures-plus-expected-basis price expectations for corn, soybean meal, and market hog prices. Table 3 reports the results of using the K-State formula with alternative methods of valuing corn, soybean meal, and market hog prices.[8] Naive price expectations (i.e., cash prices at time of weaned pig purchase) result in an average price that is closest to the USDA reported price, however, this method has greater variability in prices. Figure 2 shows USDA reported prices versus K-State formula-derived prices with naive price expectations. Using the formula in this manner would have resulted in significantly lower prices in late 1998 than were reported. Likewise, in the spring and summer of 2000, formula-derived prices would have been greater than reported spot-market prices. This suggests that the K-State formula when used with naive price expectations increases price variability, whereas, with futures-plus-expected-basis price expectations it reduced variability. The accuracy measures in Table 3 suggest that producer price expectations were most consistent with futures plus expected basis. Not surprisingly, formula-derived prices based on ex-post prices (i.e., perfect foresight) did not predict spot-market prices very well. While the perfect foresight method could not be done in real-time, it was included for comparison purposes as this approach would be the closest to true "profit sharing" so it may have merit in some long-term arrangements. Thus, the relationship between the buyer and seller as well as their attitudes towards risk may affect which method of valuing prices (i.e., price expectations) they want to use.

[8] The sample size was reduced to 155 because actual cash prices (i.e., ex-post prices) were not available over the entire 187 weeks used previously. For consistency purposes, all scenarios are evaluated over the same 155 weeks.

Lessons Learned

Discussions with numerous swine industry participants has revealed that the K-State formula has had widespread use. The formula was developed in 1995 and numerous things have been learned since then by working with producers and consultants.

1) Consultants (i.e., veterinarians and feed company representatives) played a major role in the adoption of the K-State formula. The reason for this is that large swine operations often rely on advice from outside consultants much more than from University Extension programs. This simply means that our "target audience" may be consultants rather than producers (i.e., the end user) more in the future than historically has been the case. We need to recognize the importance of taking advantage of the "leverage effect" consultants can have on educating producers about new technologies.

2) A basic understanding of the concept of how the K-State formula was developed (i.e., equal return on investment to the different production phases) varies tremendously among producers and consultants that use the formula. This suggests the importance of an educational program with regards to using the formula. For example, while consultants can provide a tremendous leverage effect with regards to exposing and educating producers to a new technology, this "advantage" can quickly become a "disadvantage" if they are uninformed themselves.

3) When producers and consultants feel something is not appropriate for their situation they can be quite innovative. The K-State formula has been modified in numerous cases to "fit" a particular situation indicating that producers and consultants may frequently alter a published formula. Unfortunately, some of these changes may be ad hoc and not necessarily consistent with the derivation

of the formula. Also, these changes can be persistent even though they may not be warranted.[9] Although there is nothing inherently wrong with these modifications, they tend to confirm that a number of producers using the formula do not understand the basic concept behind it.

4) Some producers struggle with what the appropriate numbers to "plug in" to the formula are suggesting they do not feel comfortable with using futures plus expected basis for their price expectation. An individuals' particular situation can impact how they use the formula. For example, two parties with a long-term contract with consistent pig numbers over time may choose an ex-post approach because it distributes returns more equitably even though it may generate prices that vary significantly from market observed prices at any particular point it time. On the other hand, buyers and sellers with a short-term relationship may desire an approach that corresponds to market prices more closely.

All of these issues pertaining to the use, or misuse, of the K-State formula have one thing in common — it is important to understand conceptually what the formula represents. This implies that when "tools" of this nature are developed it is important that an educational component be included because the misuse of a formula such as this may create numerous unanticipated problems.

Summary

As agriculture moves from commodity to more segmented markets and contracts, markets become thinner and public information is often scarce. In these cases market participants may rely on

[9] For example, one producer contacted the author to discuss the K-State formula he had received, however, his "version" had an additional $4/head added on. The producer assumed this was part of the K-State formula when in fact it represented a modification that somebody else had made. Most likely it represented a genetic premium for the quality of the seller's breeding herd (that has been the most common modification that the author is aware of).

formula pricing as a means of establishing a value for their products. A weaned pig pricing formula was developed because no market institution for discovering price or publicly reporting price information existed for weaned pigs. This formula (the K-State formula) was derived based on equating return on investment across the different swine production phases (farrow, nursery, and finish).

USDA began reporting prices for weaned pigs in the fall of 1997 which allows formula-derived prices to be compared to spot-market prices. All formulas considered were found to be biased predictors of spot-market prices over the 187-week time period examined. Prices derived from the K-State formula were less variable than cash prices but were statistically better predictors of spot-market prices than those derived from other common formulas. Additionally, formula-derived prices using futures-plus-basis price expectations were significantly better at predicting spot-market prices than when price expectations were based on futures prices without adjusting for basis or current cash prices.

Because USDA currently reports the prices of segregated early weaned (SEW) pigs on a weekly basis, there may be less need for a weaned pig pricing formula (i.e., contracted pigs could simply use the USDA reported price as their “formula” price). However, the analysis here indicates that a pricing formula based on equal returns on investment has merit and may be relevant as the availability of public price information becomes an issue in other industries (e.g., dairy replacement heifers, value-added crops, high quality feeder cattle). Pricing formulas can be very valuable to industry, however, if they are developed for general public use it is important that they are accompanied with an educational program.

Table 1. Parameter Estimates for K-State SEW Formula for Pricing Weaned Pigs.[a]

Variable	Parameter Estimate	Standard Error	p-value
Intercept	-0.164703	0.2399	0.4927
Corn price (CN), $/cwt	-1.570530	0.0660	0.0000
Corn price squared (CN^2)	0.058121	0.0053	0.0000
Soybean meal price (SBM), $/ton	-0.043368	0.0026	0.0000
Soybean meal price squared (SBM^2)	0.000077	0.0000	0.0000
Market hog price (MH), $/cwt (carcass)	0.971914	0.0050	0.0000
Market hog price squared (MH^2)	-0.003354	0.0000	0.0000
R^2	0.999		
RMSE	0.212		
Number of observations	546		

[a] A comparable formula was estimated for 55-pound feeder pigs and is available from the author.

Table 2. Comparison of USDA Reported and Out-of-Sample Formula-Derived Weaned Pig Prices.[a]

Variable	USDA Price	K-State Formula	Flat Price $32/head	52% of Futures [b]	Futures less $15 [c]
Mean, $/hd	29.31	30.35	32.00	28.73	25.88
Minimum, $/hd	14.66	20.03	32.00	22.46	16.96
Maximum, $/hd	40.93	39.42	32.00	34.40	33.95
Standard deviation, $/hd	6.55	4.11	0.00	3.01	4.29
RMSE, $/hd	—	4.069	7.103	4.672	5.423
MAE, $/hd	—	3.145	5.310	3.920	4.560
Bias test [d]	—	0.0001	0.0001	0.0001	0.0001
AGS test [e]	—	Base	Reject	Reject	Reject

[a] Comparisons are based on weekly prices from November 1997 though May 2001 (187 weeks).

[b] Deferred lean hog futures price ($/cwt) on a carcass basis.

[c] Deferred lean hog futures price ($/cwt) on a live-weight basis (conversion factor = 0.74).

[d] p-value associated with joint test of H_0: $\beta_0=0$, $\beta_1=1$ (from USDA Price = $\beta_0 + \beta_1$ Formula Price), rejecting null implies forecast is biased.

[e] Test of forecast accuracy relative to K-State Formula, rejecting null implies K-State formula outperforms alternative formula.

Table 3. Comparison of USDA Reported Price and K-State Formula-Derived Weaned Pig Prices for Various Price Expectation Scenarios.[a]

Variable	USDA Price	K-State Formula (price expectations scenario) Naive[b]	Futures[c]	Futures plus basis[d]	Ex-post[e]
Mean, $/hd	28.22	29.37	32.48	29.85	29.79
Minimum, $/hd	14.66	3.15	26.05	20.03	3.00
Maximum, $/hd	40.93	41.61	38.94	39.42	41.44
Standard deviation, $/hd	6.70	7.48	3.25	4.16	7.71
RMSE, $/hd	—	6.610	6.214	4.302	8.350
MAE, $/hd	—	5.654	4.863	3.358	6.246
Bias test[f]	—	0.0001	0.0001	0.0001	0.0001
AGS test[g]	—	Reject	Reject	Base	Reject

[a] Comparisons are based on weekly prices from November 1997 though October 2000 (155 weeks).

[b] Price expectations are based on cash prices at time of weaned pig purchase.

[c] Price expectations are based on deferred futures prices at time of weaned pig purchase.

[d] Price expectations are based on deferred futures prices plus expected basis at time of weaned pig purchase.

[e] Price expectations represent perfect foresight (i.e., expected prices = actual prices).

[f] p-value associated with joint test of H_0: $\beta_0=0$, $\beta_1=1$ (from USDA Price = $\beta_0 + \beta_1$ Formula Price), rejecting null implies forecast is biased.

[g] Test of forecast accuracy relative to K-State Formula using futures-plus-basis price expectations, rejecting null implies futures-plus-basis price expectations outperform alternative methods.

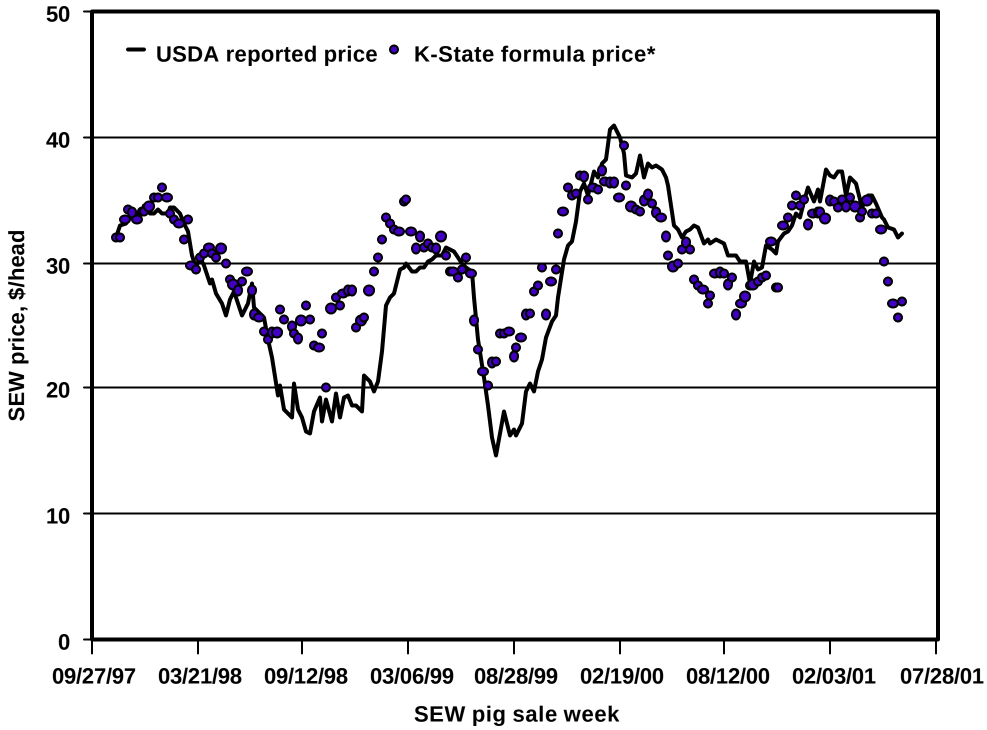

Figure 1. USDA Reported versus K-State Formula Derived Weaned Pig Price – Futures-Plus-Basis Price Expectations.

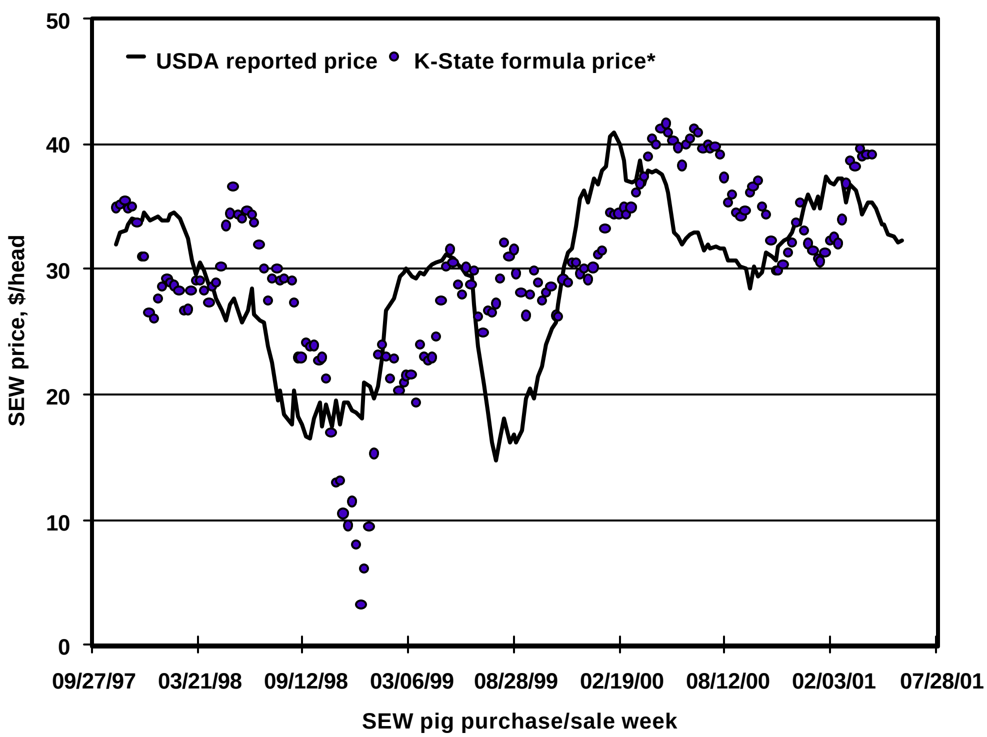

Figure 2. USDA Reported versus K-State Formula-Derived Weaned Pig Price – Naive Price Expectations.

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