IMPLICATIONS OF FEEDER PIG PRICE VARIABILITY IN VIRGINIA TELE-AUCTION MARKETS

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During the last two decades, the feeder pig industry in Virginia has undergone significant growth in the number of pigs sold and in the value of total sales, along with improvement in marketing procedures. From 1959 to 1978, the number of feeder pigs sold in state-sponsored auctions increased from 2,195 to more than 150,000 per year (Virginia Department of Agriculture). Tele-Auction sales, conducted by the Virginia Feeder Pig Association, use a conference telephone system that allows distant buyers to bid for pigs described by lot size, grade, weight, and tail docking. Pigs from various producers are co-mingled into lots that are homogeneous with respect to these characteristics. The Tele-Auction system permits out-of-state buyers to participate easily in sales, thus increasing the demand for Virginia's feeder pigs. In 1979, the Association sponsored 128 sales at 8 locations.

Although market information on each lot sold is available from a Virginia Department of Agriculture publication and from local newspaper financial sections, the feeder pig price-formation process in Virginia Tele-Auctions has not heretofore been systematically analyzed. Although information can readily be found relating to feeder pig management problems (Cooper and Smith; Hepp) and to factors affecting feeder calf prices (Brown et al.; Jamison et al.; Menkhaus and Kearl; Stout and Freund), a very limited amount of research on feeder pig price determination has been reported during the last decade. Quantitative knowledge of the relationships between various biological and economic characteristics and feeder pig prices would help to improve production and marketing efficiency, particularly for limited resource producers.

In this study, an econometric analysis of such relationships is reported. Some of the implications of the analysis for feeder pig production and marketing strategies are then discussed. In particular, price differentials among pigs differing in weight, grade, and other factors are used to identify optimal pig sale weights by season and to isolate optimal boar purchase strategies (Fisher).

VARIATION IN FEEDER PIG PRICES AND WEIGHTS

The large variation in average monthly Virginia feeder pig prices during the years 1975 to 1979 is shown in Figure 1. As expected, strong seasonality is evident. Average prices were usually higher in the late spring and fall, and generally lower through the summer and winter. The observed price variation has also been shown to be affected by several other factors, including lot size, tail docking, location, grade, weight, order of lot in sale, size of auction market, and the demand for market hogs (Elam and Sappington).

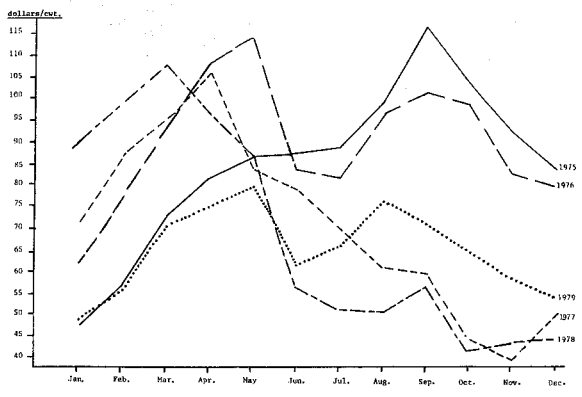

FIGURE 1. Comparison of 1975 to 1979 Monthly Mean Prices of Feeder Pigs in Virginia State Graded Sales

Pig sale weights also appear to be seasonal. Weights were relatively higher in the winter and lower through the summer and fall (Figure 2). Economic or biological reasons for this weight variation are not immediately evident, but we hypothesize that they partly have to do with the production schedules and management practices of different-sized pig operations. Harsh winter weather permits many limited resource farmers with minimal facilities to produce pigs only during spring and fall. These producers often sell

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lighter-weight pigs than better-equipped and full-time operators (Lynam). In addition, the relationship between pig sale weight and pig market price may also be seasonal. If so, increases in market weight are more strongly penalized at certain times of the year. Finally, labor competition among farm enterprises may cause pigs to be marketed at lower weights during some months (Fisher).

Annual sale summaries show that approximately 50 percent of pigs marketed in Virginia were graded U.S. 1 or 2. These higher grade pigs typically received a $2 to $6 price premium over U.S. No. 3 pigs (Figure 3), although U.S. Grade 3 pigs occasionally received prices equivalent to or greater than pigs grading U.S. 1 and 2. If all pigs were marketed at identical ages, it would be clear that the heavier pigs are those that have gained weight most rapidly. Thus, higher grades could be expected for heavier pigs of the same age. But, feeder pigs are marketed at various ages, and grading them on the basis of weight can be misleading.[1] Since higher grade pigs typically receive price premiums, the fact that grades seem to be influenced by weight favors producers who market heavier pigs. Limited resource farmers who market pigs soon after weaning would be penalized under these grading situations.

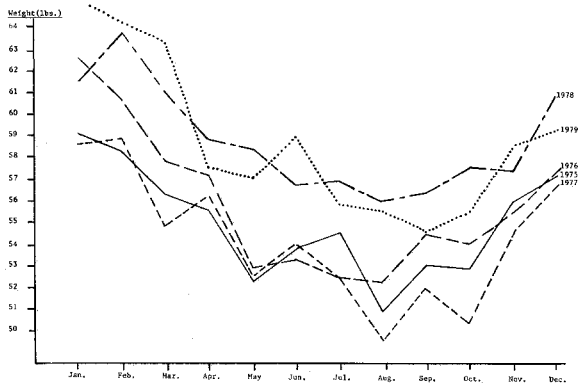

FIGURE 2. Comparison of 1975–1979 Monthly Mean Sale Weights of Feeder Pigs in Virginia State Graded Sales

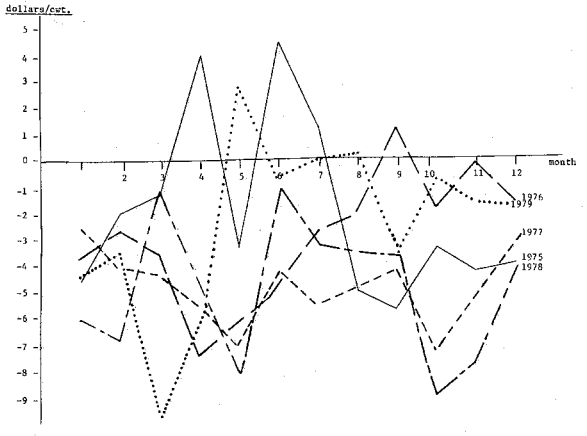

FIGURE 3. Average Monthly Discount for U.S. Grade 3 Under U.S. Grade 1 and 2 Feeder Pig Prices from 1975 to 1979 in Virginia State Graded Sales

THE ECONOMETRIC MODEL AND METHODOLOGY

Hypotheses concerning the influence of selected variables on feeder pig prices were developed. These hypotheses were based on neoclassical profit-maximization theory and on the results of previous feeder pig studies. Since previous feeder pig pricing literature is limited, literature on feeder calf price formation was used as supplementary material. The number of explanatory variables used in these studies was diverse, and a maximum of one year's data was used. Some models incorporated only linear terms, while others added nonlinear variables. In most of the studies, the authors concluded that feeder pig prices were easily predictable for application to production and marketing decisions. The expanded econometric model estimated in this study was synthesized using variables reported in this earlier research.

Lot Size. Each feeder pig buyer presumably has in mind a particular lot size that would satisfy his purchase demand while minimizing per-hundredweight handling and transportation costs. In the aggregate, then, feeder pig prices would be expected to increase with lot size up to a certain point and then decline as the optimal lot size (perhaps a truck trailer load) is surpassed (Kuehn).

Weight. During periods in which hog feeders expect positive profits, feeder pig prices per hundredweight should decrease with increases in sale weight, because expected feeding profits are allocated over more weight in heavier feeders (Lytle and Camacho). Because, as weight rises, successive increases in weight represent smaller proportionate increases, per-hundredweight feeder pig prices would normally also fall more and more slowly at higher weights (Buccola and Carmichael; White, et al.).

Grade. Based on the intentions of the grading system, it was assumed that pigs graded U.S. 3 and below would be bought at a discount from U.S. 1 and 2 pigs, all else equal.

[1] There is limited evidence to suggest grading procedures may have been biased in favor of heavier pigs during the time period analyzed in this study. Although it is not the objective of this study to test for evidence of grading bias, the percentage of pigs grading U.S. 1 and 2 increased substantially after a U.S. Department of Agriculture grading review (Fisher, p. 117).

Tail Docking. Docking eliminates tail biting, so tail-docked feeders ought to bring higher pig prices than undocked feeders. Since January, 1980, tail docking has been required of pigs sold in Virginia state-graded auctions, and the tail-docking variable was expected to provide some indication of producers' benefits from this regulation.

Hog Prices and Feeding Costs. Economic theory suggests that slaughter hog prices have a positive influence on feeder pig prices, because the demand for feeder pigs is derived from slaughter hog demand. Feed and other production costs should affect feeder pig prices negatively for comparable reasons (Lytle and Camacho; Elam and Sappington). The ratio of slaughter hog price to corn price was used to reflect the combination of these effects.

Location. Feeder pigs sold relatively far from principal hog finishing areas would be expected to bring relatively low prices because of the finishers' higher transportation costs. In Virginia, the only sale location that is geographically isolated from the major production and finishing regions is located in Marion (Fisher).

Market Size. The size of a feeder pig market, measured by its annual sales volume, could have a positive or negative effect on feeder prices, depending upon whether increases in sales volume attract proportionately greater or smaller increases in buyer demand.

Order of Sale Within Grade. The order in which a lot is sold within a grade on a given day may affect price, because buyers' interest in an auction sale tends to vary throughout the sale. Livestock prices have frequently been found to diminish on the average as a sale proceeds, all else constant (Kuehn).

In summary, our price determination model was specified as:

$$(1) \quad FP = f(LS, LS^2, WHT, WHT^2, GR3, GRUT, GR456, TD, HC, M, NPYR, ORSGR),$$

where

FP = feeder pig price, in $/cwt.,
LS = lot size, in number of head per lot,
WHT = average weight of lot, in lbs.,
GR3 = one if U.S. Grade 3; zero otherwise,
GRUT = one if Utility grade; zero otherwise,
GR456 = one if Grades 4, 5, or 6; zero otherwise,
TD = one if tail is docked; zero otherwise,
HC = hog/corn ratio (Omaha No. 1 and No. 2 hog price divided by Omaha No. 2 corn price),
M = one if sale was at Marion, Virginia; zero otherwise,
NPYR = number of pigs sold at each market in 1978,
ORSGR = order in which the lot was sold within a particular grade designation.

Significant first-order serial correlation was frequently observed in OLS estimates of these models; the significant correlations were removed by a two-stage autoregressive procedure (Baum).

ANALYSIS OF RESULTS

This model was estimated separately for each month of the 1975–79 period. Space does not permit reporting of all results, and only those for 1979 are shown in Table 1. For the most part, the 95-percent confidence interval for each 1979 coefficient contained the corresponding coefficient for that month in each previous year. Nevertheless, the between-year variation in coefficients, even for a given month, were greater than expected or implied by prior research, and the 1979 results should be viewed with this in mind.

Lot size did not appear to be a very significant price determining factor in 1979, although in prior years, lot size increases were frequently associated with increasing, then decreasing, prices per hundredweight.[2] The minimum number of head per lot associated with the maximum price per hundredweight was 108 pigs and depended on the month and year. Lot size was more consistently significant as a price factor in the spring and early summer.

Feeder pig prices in 1979 and in other years declined with increases in sale weight, but, for the most part, the rate of price decline decreased at higher weights. In common with earlier years, pigs grading U.S. 3 in 1979 were usually sold at prices significantly lower than the U.S. 1 and 2 group, particularly during winter months. Discounts on No. 3s, compared to 1s and 2s, were volatile, ranging from $9 per hundredweight to zero. Price premiums on No. 3s were never statistically different from prices of other grades. Grades below U.S. 3 always received strong price discounts under U.S. 1s and 2s, and tail-docked feeders generally received $2 to $5 per hundredweight premiums over nondocked feeders.

For eight months during 1979, the hog-corn ratio had a significant and positive effect on feeder pig prices as had been hypothesized. Dur-

[2] Unless otherwise specified, the 5 percent level of significance is implied.

TABLE 1. Estimated Monthly Regression Coefficients for Variables Affecting the Virginia Feeder Pig Price Per Hundredweight in 1979[a]

Variable	January	February	March	April	May	June	July	August	September	October	November	December
INT	-27.3062	-67.7409	97.7946	42.1846	-36.7824	5.4269	-20.7772	7.1508	-40.6927	-88.7188	19.0724	.8818
LS	.0483	.0633	.01679	.0138	.03654	-.0054	-.00624	.0214	-.00966	.00071	-.0028	.0064
	(1.85)	(1.27)	(.74)	(.49)	(2.38)	(.46)	(-.44)	(1.38)	(-.52)	(.06)	(-.23)	(-.68)
LS^2	-.0001	-.000212	-.000013	-.000084	-.00007	.000007	.000009	-.00007	-.000001	.000015	.000008	-.000001
	(-1.09)	(-.88)	(-.22)	(-1.02)	(-1.99)	(.25)	(.26)	(-1.50)	(-.006)	(.64)	(.27)	(-.032)
WHT	-.8824	-.6481	-1.0496	-.6432	-.8656	-.5337	-.77791	-.5041	-.5380	-.2601	-.1583	-.00269
	(-7.51)	(-3.16)	(-8.79)	(-5.02)	(-7.44)	(-6.93)	(-8.58)	(-6.18)	(-5.33)	(-3.43)	(-1.63)	(-.025)
WHT^2	.0035	.0011	.00306	.001489	.0029	.0022	.004411	.00198	.0024	.0013	.00056	-.00042
	(5.15)	(.90)	(4.31)	(2.02)	(4.17)	(4.55)	(7.08)	(3.81)	(3.95)	(2.46)	(.94)	(-.59)
GR3	-4.6060	-3.6089	-9.7326	-6.2990	2.6537	-.8509	-.0463	.1566	-3.6091	-.9512	-1.7684	-1.8911
	(-2.41)	(-1.01)	(-4.74)	(-2.68)	(1.13)	(-.53)	(-.029)	(.11)	(-2.51)	(-.93)	(-1.26)	(-1.46)
GRUT	-22.7678	-23.5889	-36.0248	-27.5953	-10.6523	-11.2270	-11.8028	-7.1635	-15.1841	-8.9384	-13.3646	-11.7273
	(-9.23)	(-5.44)	(-12.44)	(-8.92)	(-3.62)	(-5.62)	(-6.12)	(-3.82)	(-7.98)	(-6.31)	(-7.66)	(-6.95)
GR456	-23.3709	-22.4056	-28.5833	-24.7021	-11.9207	-15.0514	-9.4053	-7.3404	-12.6239	-9.1274	-12.2831	-12.3371
	(-10.82)	(-4.94)	(-11.02)	(-8.74)	(-4.79)	(-8.22)	(-5.45)	(-4.46)	(-6.91)	(-6.91)	(-6.91)	(8.06)
TD	4.8832	3.5819	5.0686	5.7615	2.9728	2.7911	1.1943	5.0295	5.0564	2.0780	3.2235	2.1739
	(2.87)	(1.21)	(3.29)	(3.09)	(2.33)	(3.03)	(1.29)	(5.52)	(3.30)	(1.73)	(2.07)	(1.61)
HC	7.7596	12.4672	-1.3781	2.6295	13.7508	4.0993	10.8697	3.2760	9.2838	12.3332	-.1180	2.9650
	(4.91)	(1.91)	(-1.42)	(.34)	(2.68)	(3.29)	(1.93)	(.83)	(4.24)	(8.86)	(-.038)	(3.31)
M	-19.5827	-24.1975	1.3781	-16.3262	-20.4110	-20.4406	-12.9925	.2669	2.0347	-5.0272	-2.7531	-4.0308
	(-5.56)	(-4.17)	(.31)	(-3.14)	(-2.65)	(-5.95)	(-3.54)	(.08)	(.66)	(-2.44)	(-.85)	(-1.58)
NPYR	.000096	-.000143	.000225	-.00016	.000014	-.000047	.00007	-.00002	-.000016	.00017	.000079	-.000026
	(1.47)	(-1.02)	(3.21)	(-1.72)	(.15)	(-.73)	(1.07)	(-.33)	(-.31)	(4.74)	(1.33)	(-.48)
ORSGR	-1.4082	-1.5223	-2.7561	-1.9924	.16025	-.46046	-.4431	-.0597	-.9326	-.2162	-.6929	.03796
	(-3.04)	(-2.23)	(-6.16)	(-4.24)	(.36)	(-1.51)	(-1.29)	(-.17)	(-2.44)	(-.67)	(-1.79)	(.113)
R^2	.89	.88	.92	.89	.78	.81	.73	.74	.69	.70	.72	.76
M.S.E.	45.33	58.64	51.72	41.08	64.57	24.95	24.59	23.71	32.53	17.87	20.03	15.54

[a] The numbers in parentheses are t-values.

ing the summer months from 1975 to 1979, the effect was not often significant. When significant, an increase of one unit in the ratio was accompanied by a $2- to $14-increase in feeder pig prices per hundredweight. Some situations were found where the ratio had a significant negative influence on price. These results somewhat dampen the reliability of the hog-corn ratio as a price predictive variable. Perhaps a more complicated functional representation, including a lag structure, would have produced more consistent results.

Sales at the isolated Marion location usually brought significantly lower prices than elsewhere. This finding agrees with the hypothesis stated previously.

Greater market size, measured by annual market volume, was not often associated with significantly higher average feeder pig prices during the sample period. Even when the estimated coefficients were significant, the addition of each 1,000 pigs to a sale resulted in less than a $0.25 increase in average per-hundredweight price. Hence, it appears that a producer should not let auction size influence his choice of market.

Finally, Table 1 shows that feeder prices between January and April, 1979, had a tendency to decline significantly during the course of a sale. Significant negative relations between price and the order in which a lot was sold within a grade were often evident in earlier years as well. When the relation was significant, prices fell $1 to $5 per hundredweight for each single position advance.

Weight and Grade Effects

An interesting aspect of Table 1 is that the relationship between feeder sale weight and price varies substantially from month to month. It is

somewhat negative in the late winter, very negative in the spring and summer, and relatively flat in the fall (completely flat in November and December). This probably reflects the higher cost of winter fattening and consequently reduced demand for light feeders relative to heavy feeders in the early winter. It was expected that increases in feed prices would decrease the rate at which feeder pig prices fall with sale weight, because feed price increases tend to decrease hog finishers' break-even prices for light pigs more than they do for heavy pigs. On the other hand, increases in slaughter hog prices would tend to bid up prices of light feeders relative to heavy ones, because a given hog price increase is allocated over fewer pounds in lighter feeders.

To test these relationships, the mean effects on per-hundredweight price of increasing feeder pig sale weight by one pound (DPDW) were calculated from the regression results for each month during 1975–79. These effects were then regressed on the current hog-corn ratio (HC), three seasonal dummies (D2 for spring, D3 for summer, D4 for fall), and an annual trend variable (Y). The results were as follows, with t-values shown in parentheses:

$$\begin{aligned}(2)\quad DPDW = {} & .2960 - .0233\,HC - \\ & (3.37) \quad (-4.96) \\ & .0651\,D2 - .0351\,D3 + \\ & (-1.69) \quad (-0.90) \\ & .1079\,D4 - .0563\,Y \\ & (2.79) \quad (-5.84)\end{aligned}$$

$R^2 = .60 \qquad MSE = .011 \qquad n = 60$

These estimates are consistent with the analysis by White et al. insofar as they suggest that increases in the hog-corn ratio do raise the price discount on pigs for added weight. An increase of 10 in the hog-corn ratio raised by $0.23 per hundredweight the amount by which feeder pig prices would be expected to fall for every one-pound gain in sale weight.

Variations in feed prices may also be used to explain monthly changes in the price difference between U.S. 1s and 2s and U.S. 3s (coefficients of GR3 in Table 1). A drop in feed prices would be expected to favor prices of U.S. 1s and 2s over prices of U.S. 3s, if the former are perceived by hog finishers as being more feed efficient than the latter. To measure this, a model was specified relating the monthly average price differential between grades U.S. 1 and 2 and U.S. 3 (DPDGR) to the same seasonal, trend, and hog-corn ratio factors as in (2):

$$\begin{aligned}(3)\quad DPDGR = {} & 4.5209 - .4726\,HC - \\ & (2.08) \quad (-4.05) \\ & .6707\,D2 + 1.722\,D3 + \\ & (0.70) \quad (1.70) \\ & .6634\,D4 - .2569\,Y \\ & (0.69) \quad (-1.08)\end{aligned}$$

$R^2 = .27 \qquad MSE = 6.833 \qquad n = 60$

Increases in the hog-corn ratio caused pig buyers to bid up prices of U.S. 1s and 2s relative to U.S. 3s of the same weight. More negative DPDGR values in equation (3) represent greater premiums for 1s and 2s so that, on the average, an increase of 10 in the hog-corn ratio increased the premium for U.S. 1s and 2s by $4.73 per hundredweight. Consistent seasonality in the estimated residuals was not apparent. Nevertheless, these conclusions are tentative, because the low R^2 indicates that other factors affect grade price differentials, and that there may be some model specification bias.

IMPLICATIONS FOR FEEDER PIG PRODUCERS

Individual feeder pig producers can control only certain aspects of pig production and marketing, including herd quality, weight, and sale location. In the present research, the size of a marketed lot did not have a predictable impact on price in most months; also, an individual producer can rarely control lot size because lots are co-mingled from various sources by auction market personnel. It is not even clear that a producer can consistently improve his sales prices by selecting relatively large markets. Moreover, recent transportation cost increases have tended to discourage utilization of distant markets simply on the basis of their size.

On the other hand, herd quality is an important aspect of livestock operations that can be controlled by producers. If price premiums for U.S. 1 or 2 pigs are substantial and are expected to remain large, producers may profitably increase herd quality through an investment in higher quality boars. For example, consider a situation in which a producer is considering replacing his present, average quality boar with a higher quality one at a net cost of $150. It is assumed that the herd consists of 20 sows producing 150 40-pound pigs per year, divided equally between U.S. 1 and 2 and U.S. 3 grades. If the producer expects by the boar upgrading to produce 25 more U.S. 1 and 2 pigs and 25 fewer No. 3s, he will need to receive an extra $1.50 per head ($3.75 per cwt.) for all his U.S. 1 and 2 pigs in order to break even, ignoring interest and miscellaneous costs. At the intercept corresponding to mean season and year in Equation 3, a hog-corn ratio of at least 18.0 would be necessary before the price premium for U.S. 1s would normally exceed

$3.75, thus justifying the purchase of the higher quality boar. From 1975 through 1979, the hog-corn ratio has been greater than 18.0 about 60 percent of the time. Given these assumptions, the use of high quality boars seems almost justified on the basis of improvement in feeder pig grades alone.

The weight at which to sell pigs is also a critical decision for many feeder pig producers, particularly those with limited resources, if alternative auction sales dates are available. Traditionally, feeder pigs have been sold very soon after weaning, at a weight of about 40 pounds. This has resulted in a 40-pound weight as a standard designation of feeder pigs in production budgets. In actual feeder pig sales, most animals are heavier than 40 pounds because regional sales are usually two weeks to one month apart. For example, the average sale weight at Virginia feeder pig sales has been decreasing in recent years, but the average weight was still 53 pounds in 1979 (Virginia Department of Agriculture). However, in Virginia and perhaps elsewhere, the results of this research suggest that it is more profitable, in most circumstances, to sell pigs at heavier than at lighter weights. The costs of carrying a feeder pig to 65 pounds from 40 pounds are approximately $0.39 per pound in a complete pasture system (Table 2). During each month in which marginal revenue with respect to weight in Table 1 is greater than $0.39 per pound, net revenue would increase with market weight, other factors constant.[3] During 1975 to 1979, marginal revenues exceeded $0.39 in most months, with the principal exception of fall 1979. Thus, heavier weight marketings appear to be generally associated with higher profits than are lighter weight marketings.

TABLE 2. Estimates of the Variable Costs of Carrying a 40-Pound Feeder Pig to 65 Pounds in a Complete Pasture System (Fisher)

Items	Quantity	Amount
		-----Dollars-----
FEED[1]/		
Corn[2]/	43.00 lbs.	2.15
Soybean Meal[3]/	10.75 lbs.	1.39
Other Feed Ingredients	1.64 lbs.	0.30
Total Feed Costs	55.39 lbs.	3.84
OPERATING EXPENSES		
Electricity		0.14
Vet and Medicine		0.53
Grinding		0.36
Interest on Feed[4]/		0.35
Labor Expense		3.31
Repairs		0.67
Hauling and Marketing		0.48
Total Operating Expenses		5.84
TOTAL COSTS		9.68
AVERAGE COST PER LB.		0.39

[1] Rate of gain is 2.2 lbs. of 16% protein meal feed.
[2] Corn Price is $2.80 bu.
[3] Soybean meal is $13 cwt.
[4] 12% per year and ⅓ year storage is 4%.

SUMMARY AND CONCLUSIONS

The results of this multi-year analysis indicate that monthly feeder pig prices are influenced by several economic factors that change seasonally, and by other factors that vary across markets. Where consistently significant parameter estimates of price determining variables exist, producer decision criteria are straightforward when marginal production costs are known. However, estimated coefficients of price determining factors vary considerably in significance, sign, and magnitude. This contrasts sharply with the presumption of much previously published literature that exogenous influences on feeder pig prices are predictable in magnitude.

Nevertheless, it has been shown that conclusions can be drawn from the present research that have important management implications. Most important is that the optimal weight at which to sell pigs varies throughout the year. In most months, limited-resource producers would maximize expected net revenues by selling heavier pigs, weighing at least 65 pounds. However, this does not hold true for months when large price discounts for added weight are expected to occur. Second, farmers may find that investments in higher quality boars to improve pig quality are economical only during periods of relatively high prices. However, high quality boars also improve production, hence lower costs and/or increase revenues in other ways.

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[3] The total revenue function is calculated by multiplying the estimated pig price determination equation (Equation 1) by average monthly weight. The derivative of this function, with respect to weight, is the marginal revenue function.

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