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Marvin Hayenga, Joel Propst, Michele Mansfield,
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SHORT-TERM PRICE FORECASTING MODELS FOR CATTLE AND HOGS

Marvin Hayenga,
Joel Propst,
Michele Mansfield, and
Gene Futrell*

In the more volatile livestock market environment that developed in the 1970s and continues in the 1980s, it is an increasingly important and more difficult task to accurately assess the likely direction and magnitude of changes in market prices. While many market analysts have been trying various sophisticated approaches over the years (see Brandt for a survey of the recent literature), the best forecasters are probably correct regarding the direction of price change only 70-80 percent of the time, and many do not come close to that level of accuracy. Because a small improvement in forecasting accuracy can lead to significant improvements in the financial performance of farmers and ranchers, meat packers, and merchandisers,

*The authors are associate professor of economics, graduate assistant, graduate assistant, and professor of economics, respectively, in the Economics Department of Iowa State University at Ames, Iowa.

market price forecasting remains an area of investigation where small gains can have important practical benefits.

The objectives of our study were:

1. Determine the principal factors influencing recent quarterly and monthly average market price behavior for fed cattle and hogs,

2. Develop updated estimates of key market interrelationships which could be incorporated into simple or complex price forecasting procedures, and

3. On a preliminary basis, test and evaluate the usefulness of these estimates in forecasting applications.

We hope to improve our ability to explain why prices behaved as they did in the 1970s, and use that knowledge in explaining and forecasting price behavior more effectively in the 1980s.

To achieve these objectives, we estimated the influence which numerous market factors had on price during the 1970-79 period using multiple regression techniques. The basic model which we formulated to explain quarterly and monthly average price behavior for fed cattle and hogs was:

$$\text{Average market price, cattle or hogs} = f\left[\begin{array}{l}\text{Beef Q, Pork Q, Broiler Q, Income,} \\ \text{Other demand influences, Monthly or} \\ \text{quarterly dummy variables}\end{array}\right]$$

This basic model is quite similar to one estimated by Hayenga and Hacklander based upon market behavior in the 1960s, so the results should also provide some interesting insights into the changes in the relative influence of these price-determining influences over the last 20 years.

Assuming that cattle, hog, and broiler production are primarily predetermined in a quarter or a month, and that their meat products are competitors, we expect negative signs on the slope coefficients, with their sizes related to their degree of substitutability. The income influences would be expected to be positive, as would the impact of other competing goods reflected in the consumer price index of GNP implicit price deflator. Other demand influences, which might have had more impact on some meat products than others in the 1970s, include rate of unemployment, number of women in the work force, and expenditures in restaurants. Quarterly or monthly dummy variables were incorporated to reflect seasonal influences like temperature and holidays on the market price level.

The equations were specified in log-log format so that the price and cross-price flexibilities would be estimated directly. The estimated slope (flexibility) coefficients are easily interpreted as the percentage change in the cattle or hog price (the dependent variable) associated with a one percent change in the independent variables incorporated into the equation. Since all independent variables were considered predetermined or exogeneous, the ordinary least squares method was used to estimate the individual equations.

Actual values of the independent variables during January 1980-June 1981 were used to test the forecasting accuracy of both relatively simple and more complex models which performed well in explaining price behavior during 1970-79. Because the quarterly and monthly

models were quite similar in structure and results, we will focus our discussion on the monthly models.

Hog price forecasting models

The three most important factors explaining interior Iowa, U.S. 1-2, 200-240 lb. barrow and gilt price variations during 1970-79 have been pork and beef production and consumer personal income (see Table 1). Pork production and income alone, in conjunction with seasonal demand shifters, explained 91 percent of monthly average live hog price variations during the last decade.

The simple and complex monthly models provided similar estimates of the percentage price impact of a one percent change in daily hog slaughter (approximately -2.0). This is substantially higher than the 1960s estimate (-1.4) by Hayenga and Hacklander, perhaps because pork now is more extensively processed and differentiated from other meats, and more of a staple in the diet for a higher income population. Given the large cyclical and seasonal variability in hog slaughter rates, an accurate forecast of the pork slaughter rate clearly is the most critical factor in successful short-term price forecasting. This also brings out the importance of accuracy in the USDA Hogs and Pigs surveys, which are the basis for most short-term slaughter forecasts; a three percent error would lead to a six percent error in the corresponding price forecast.

Table 1. Monthly Hog Price Equations (1970-1979)

Independent variables	Dependent Variable: Interior Iowa No. 1-2, 200-240 lbs. Market Hog Price (in log form)	
	Simple Model	Complex Model
log Constant Term	0.9455	2.6866
log Pork Q/Day	-1.9672**	
log $\frac{\text{Pork Q/Day}}{\text{Pop}}$		-2.0798**
log $\frac{\text{Beef Q/Day}}{\text{Pop}}$		-0.5843**
Log $\frac{\text{Broiler Q/Day}}{\text{Pop}}$		-0.3240[1]
log TPI	0.9580**	
log $\frac{\text{TPI/Pop}}{\text{CPI}}$		3.0792**
log CPI		0.4729**
Monthly dummy variables:		
Feb	-0.0145	-0.0316
Mar	0.0128	-0.0024
Apr	0.0056	-0.0103
May	-0.0274	-0.0299
June	-0.0613	-0.0588
July	-0.1097	-0.1241
Aug	-0.0549	-0.0568
Sept	-0.0004	0.0092
Oct	0.0152	0.0276
Nov	0.0393	0.0309
Dec	0.0091	-0.0100
R^2	.906	.944
D.W.	.580	1.400

** Significantly different from zero at the one percent level.

[1] Significantly different from zero at the thirteen percent level.

Definition of Variables:

Pork Q = Total U.S. commercial hog production in the month, in millions of pounds, carcass weight.

Beef Q = Total U.S. commercial beef production in the month, in millions of pounds, carcass weight.

Broiler Q = Total federally inspected broiler production in the month, in millions of pounds.

Day = Number of full slaughter days in the month. Normal weekday = 1. Weekday holidays = 1/2; Saturdays = 1/3; Saturday holidays and Sundays = 0.

Pop = U.S. civilian population, in millions.

TPI = Total U.S. personal income (before taxes), annual rate in billions of dollars.

DPI = Total U.S. disposable personal income (after taxes), annual rate in billions of dollars.

CPI = Consumer price index, 1967 = 100.

IPD = GNP implicit price deflator, 1972 = 100, seasonally adjusted.

UnRate = Civilian unemployment rate, all workers (%).

Women WF = Number of women over age 20 employed in the work force, in thousands.

Rest Exp = Consumer expenditures in restaurants (eating and drinking places), in millions of dollars.

% Fed Sltr = The percentage of total commercial slaughter contributed by fed steers and heifers.

Monthly Dummy Variables = Binary (0,1) variables; 1 if the price is for that month, 0 if it isn't. January is the base month.

R^2 = The proportion of variation in the dependent variables explained by the independent variables; coefficient of determination.

D.W. = The Durbin-Watson statistic, a measure of the degree of autocorrelation of the residuals.

In the complex model, putting daily slaughter rates on a per capita basis and adding more demand influences increased the proportion of price variation explained to 94 percent. While the beef slaughter rate exhibited a significant competitive price impact in the complex model, and the broiler slaughter rate exerted a slight influence on hog prices, their marginal contribution to explaining historical price behavior was quite small. Putting income on a real per capita basis also slightly enhanced the ability of the complex equation to explain price behavior, as did the addition of the consumer price index; both had a significant, positive impact on hog prices.

The pattern of the monthly variable coefficients suggests that seasonal demand typically has been strongest in the fall and early winter period, with some demand strength noted around Easter.

A number of other potentially important explanatory variables were examined. While pork cold storage stocks had a significant impact on hog prices in the 1960s (Hayenga and Hacklander), they did not appear to have a significant effect on hog prices in the 1970s. The prime interest rate, unemployment rate, and meat packer wage rates generally did not make a significant contribution to explaining hog price fluctuations. Similarly, women in the work force, percent sow slaughter, and a "nitrite scare" dummy variable did not significantly add to our ability to explain hog price variations in the 1970s.

These models can be used in their entirely to forecast hog prices, or the individual coefficients associated with the primary price influences can be used as rough approximations of the likely price impact

of a change in a particular variable. For example, if a new Hogs and Pigs report led you to expect a five percent increase in slaughter next month compared to either last year's slaughter level or your most recent forecast, the price impact can be quickly approximated by multiplying the percentage change in slaughter times the estimated coefficient (a price flexibility of -2) to get the expected price change (-10%). In similar fashion, a ten percent increase in nominal incomes would result in slightly less than a ten percent increase in price (versus your previous price or price forecast).

Based upon our analysis of 1970-79 hog market interrelationships, it appears that a single predictive model incorporating pork slaughter, personal income, and seasonal demand shifters would be likely to provide reasonably accurate price forecasts. Taking several more factors into account generally would not be expected to greatly enhance forecasting accuracy. To test the forecasting accuracy of these simple and complex models, actual values of the independent variables during January, 1980-June, 1981 were used to forecast prices during that 18-month period, and then compared to actual prices.

The year 1980 and the first half of 1981 proved extremely perplexing to many price forecasters in the livestock and meat sector, when some extreme production changes, hot summer weather, high inflation rates, and recessions coincided. Thus, this was a tough testing period for our models. During the 18-month test period, both models forecasted the major hog price movements quite well, though neither

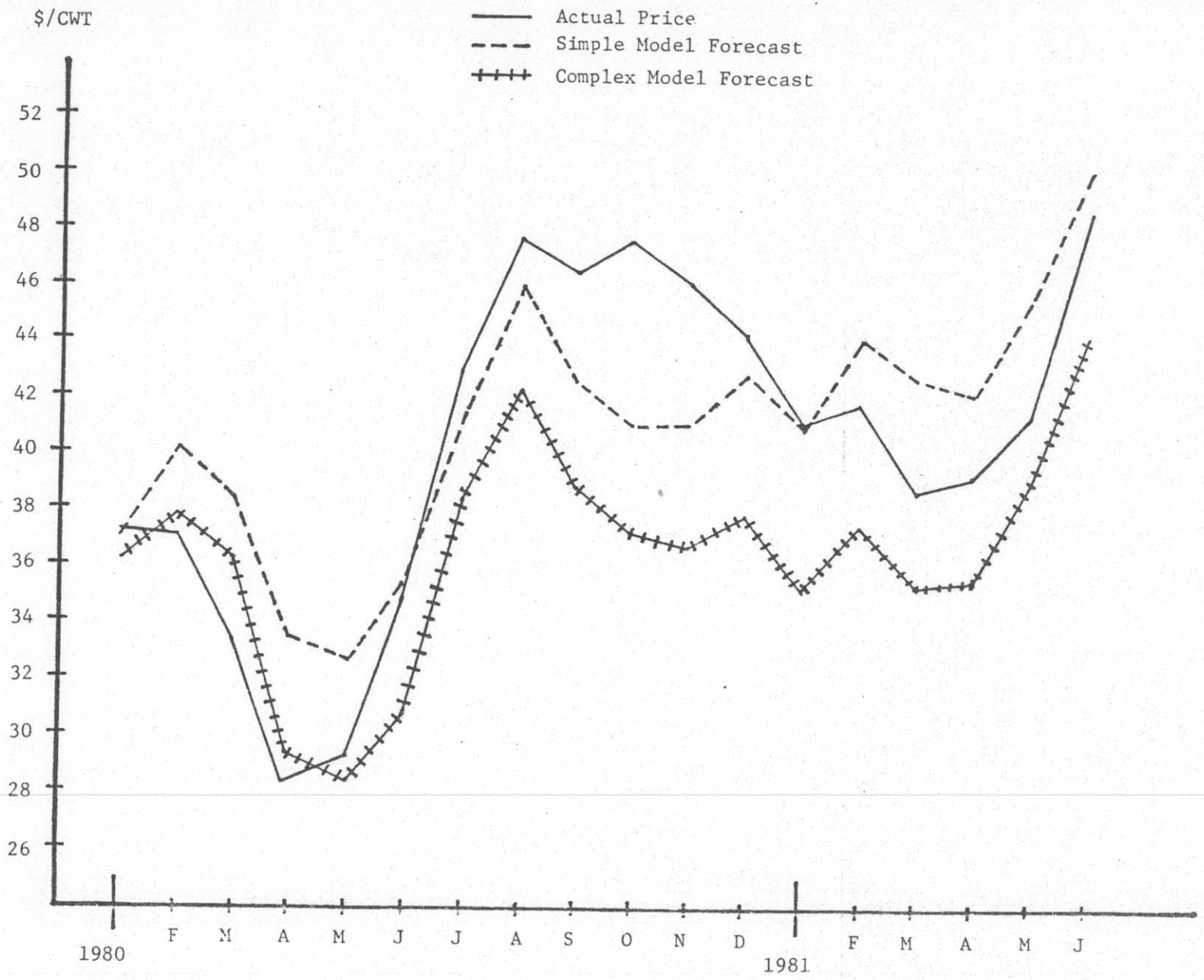
was very satisfactory in accurately capturing price levels (see Figure 1). The average absolute forecasting error for the simple model was $2.96/cwt., and $4.36/cwt. for the complex. The complex model generally underpredicted hog prices, with a downward bias averaging $3.85/cwt., while the simple model had a slight upward bias ($.71/cwt.). The simple model forecast the direction of price change correctly 65 percent of the time, while the complex model level of accuracy was 76 percent.

Quarterly price models were also developed and were specified much the same as the monthly equations. Quarterly results were generally similar to the monthly forecasting results, with a similar error pattern. The quarterly average absolute error was $2.97/cwt. for the simple model and $3.17 for the complex model, with average errors of +$1.59 and -$3.17/cwt., respectively.

To diagnose some possible reasons for forecast inaccuracies, examining the pattern of errors and relating them to the prevailing market environment may prove helpful.

Hog prices gyrated from a low of $28 in April 1980 to just under $48 in November; thus, in moving from 1980s low to that year's high, the hog price increased 67 percent. The first half's combination of large total meat supplies (especially pork), sizeable cold storage stocks and a recession caused the hog market to move further down than was forecast using our best simple model. We think that our simple monthly forecasts were generally too high in 1980s first half because nominal income figures were used, rather than real incomes

Figure 1
ACTUAL VS. FORECAST
INTERIOR IOWA HOG PRICE



(the complex model forecast prices quite well in the first half of 1980). This was followed by a rapid cyclical and seasonal cutback in pork supplies during 1980's second half, which caused a larger upside price reaction than was forecast using either the simple or complex forecasting models. The unexpected high prices in the last half of 1980 appear to be partly due to a compression of retailers' margins when farm prices surged, and partly due to high pork belly futures prices which encouraged unusually high storage demand for pork products in late fall, adding to the current demand for pork and pulling prices higher than otherwise would have been expected.

In 1981, the simple model's overestimate of price levels might be attributable to very high pork stocks and broiler slaughter which were not considered in the model. In some cases, these factors may be worth building into the next generation of forecasting models even though they may not play an important role very often; however, it may be preferable to keep the model simpler and make subjective adjustments due to these external forces based upon an ongoing evaluation of recent forecast errors, likely causes, and the likelihood of the error persisting in the future.

Fed cattle forecasting models

Very similar simple and complex cattle price forecasting models were also estimated (see Table 2) and tested. In both equations, commercial beef production, commercial pork production, and per capita real disposable income were all highly significant influences on choice

Table 2. Monthly Cattle Price Equations

Independent Variables	Dependent Variable: Choice Steer Price, 900-1100 lbs. Omaha, in log form, ¢/cwt.	
	1970-79 Simple Model	1970-79 Complex Model
log Constant Term	16.019	21.347
log Beef Q/Day	-1.327**	-1.436**
log Pork Q/Day	-.319**	-.362**
log $\frac{\text{DPI/Pop}}{\text{IPD}}$	3.891**	3.432**
log Women WF		-1.811[1]
log UnRate		-.221*
log Rest Exp		-.709**
log % Fed Sltr.		-.209**
log IPD		2.333**
Monthly dummy variables:		
Feb	-0.332	-.0363
Mar	-.0436	-.0026
Apr	-.0222	.0075
May	-.0226	.0296
June	-.0235	.0361
July	-.0373	.0133
Aug	-.0315	.0326
Sept	-.0129	.0344
Oct	.0100	.0403
Nov	-.0150	.0029
Dec	-.0475	-.0144
R^2	.89	.93
D.W.	.70	.11

** Significantly different from zero at the .01 level.
* Significantly different from zero at the .05 level.
[1] Significantly different from zero at the .09.

steer prices (Omaha) and had the expected signs. The simple model explained 89 percent of the variation in choice steer prices during 1970-79, while adding several more variables in the complex model, including several variables reflecting some broad social trends in our society during the 1970s, increased the proportion of the price variation explained to 93 percent.

As the share of commercial beef production contributed by steers and heifers (usually from feedlots) increased, the choice steer price typically declined, reflecting the greater competitive impact of fed cattle (versus other slaughter classes) on choice cattle prices. The implicit price deflator had a significantly positive relationship with choice steer prices, reflecting the competitive impact of other consumer goods and services. In addition, the implicit price deflator also proved preferable to the consumer price index in deflating the income variable, in contrast to the hog price models where the consumer price index provided a slightly better fit.

Other factors influencing prices in the complex model were the number of women in the work force, the unemployment rate, and consumer expenditures in restaurants. While we expected unemployment to have negative effects upon beef demand and cattle prices, it was somewhat surprising that restaurant expenditures had a negative sign, since many analysts would expect rising restaurant expenditures to lead to a higher demand for beef. However, this result may suggest that restaurant customers tend to order dishes normally not prepared at

home, such as seafood. Also, since much of a meal price includes services, the customer may not consume as much beef as if the same amount of money were spent on hamburger, steaks, or roasts consumed at home. The monthly dummy variables indicate that seasonal demand patterns are not strong, but demand is strongest in the fall months, and tends to drop off near Christmas due to the holiday demand for hams and turkeys.

Since the model is estimated in the log-log form, all coefficients represent price flexibilities or percentage price impacts. For example, if beef production for November is estimated to be 10 percent higher than a year ago, holding all other factors constant, we can expect prices to be 13-14 percent lower in November.[1]

In contrast to the Hayenga-Hacklander estimates based on 1962-68 data, the models estimated over the 1970-79 period indicate that the cattle price impact of pork production has increased since the 1960s.[2] Compared to the 1960s results, cold storage stocks of pork and percent cow slaughter no longer appear to significantly influence fed cattle prices.

In addition to the variables shown above, others were explored as possible price influences, and found to be either insignificant, to have an incorrect sign, or both. Broiler production was found to have a significant effect, but consistently had a positive coefficient and was eliminated from the model. When U.S. population was incorporated in the model, it was found to have an extremely high price

impact during 1970-79, perhaps due to spurious correlation with other trend variables; the model incorporating population as a separate variable proved to be extremely inaccurate in forecasting 1980-81 prices. In addition, net beef and veal imports, wage rates in the meat packing industry, average carcass weights, the prime interest rate, and the consumer price index had no significant effect on monthly choice steer prices.

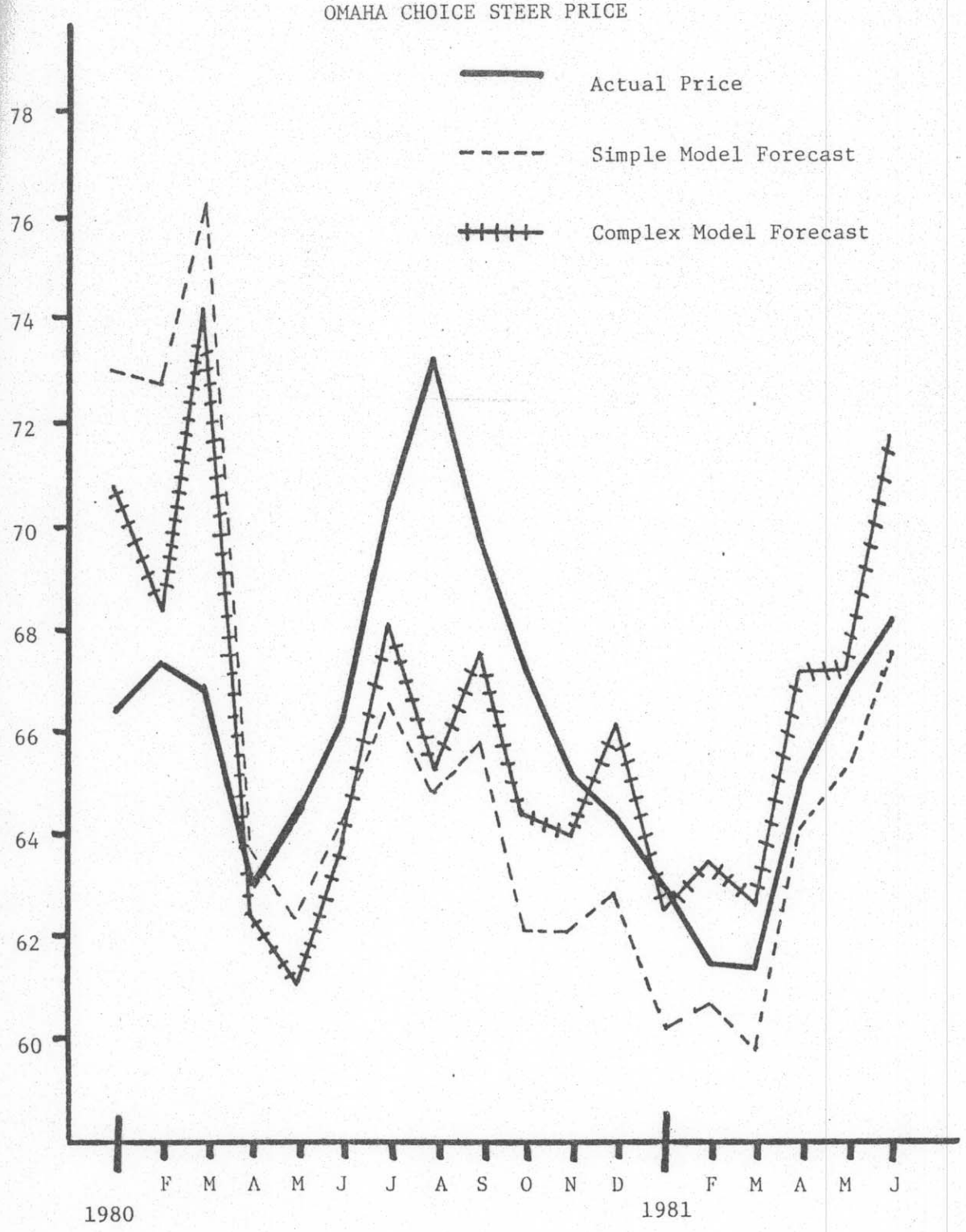
The simple and complex equations were tested over the January 1980-June 1981 period, and both forecast reasonably well (see Figure 2). But both models occasionally missed the magnitude of the price changes. The complex model was more accurate, with an average absolute error of $2.68/cwt., with a slight upward bias of $.07/cwt. The average absolute error for the simple model was $3.33/cwt. while the average error was $-.93/cwt., e.g., a slight downward bias. Both the simple and complex models were surprisingly accurate in 1981, registering average absolute errors of $1.38 and $1.74, respectively. It is interesting that models estimated using nominal per capita income per capita income over-predicted prices by an average of $6.80 during this same 1981 period.

Most of the forecasting error during the 1980 period was due to particularly large errors noted in March, July, and August. While it is difficult to pinpoint the causes, the extremely large pork production levels in conjunction with the declining economy may have contributed to the lower prices observed in March compared to the

Figure 2

ACTUAL VS. FORECAST

OMAHA CHOICE STEER PRICE



forecasts. In July and August, the extremely hot summer weather led to a well-publicized reduction in broiler production and slowed production of beef and pork compared to prior expectations; these may have partly contributed to the market price exceeding forecast price levels.

In the quarterly models which were estimated (but not shown in the table), the simple model was very similar to the monthly model, but the only significant variables in the complex model were beef production, pork production, per capita real income, and the implicit GNP price deflator. Thus, the significant factors influencing quarterly average prices closely resembled the results shown for the monthly models. The beef, pork, and income price impacts were approximately the same magnitude on a quarterly or monthly basis.

The complex quarterly models had an average absolute error of $2.37/cwt., while the simple quarterly models had an average absolute error of $5.15 during the January 1980-June 1981 test period.

Summary and Conclusions

Our analysis of factors influencing quarterly and monthly cattle and hog prices during the 1970s suggests that a few key market factors explain a high proportion of recent price fluctuations. Forecasters, who can accurately predict beef and pork production levels and consumer disposable or personal income levels, should be able to account for a high proportion of the price fluctuations in these

markets. The percentage price changes associated with a one percent change in production or income levels in the 1970s can serve as useful guidelines or rules-of-thumb for market analysts to use in explaining and predicting market price behavior. In Table 3, the approximate price and income impacts associated with changes in the most important cattle and hog market price influences in the 1970s are summarized, based on a number of monthly and quarterly models varying slightly in model specifications. When a change in slaughter rates or economic prosperity seems likely, their approximate price impact can be quickly determined using these percentage price impact estimates and the price levels 12 months earlier as the base for comparison (Figure 3). The relative importance of those factors (and their variability) also give a clear indication where time and money would be better spent in monitoring and forecasting the causes of price change, and ultimately improve your price forecasting accuracy.

Other factors also have been and will continue to be price influences that usually can be overlooked with little loss in accuracy, but which occasionally exert an influence that can significantly affect forecasting results. Based on our analyses to date, relatively simple price forecasting models based on recent market behavior generally appear to anticipate the direction of major price movements as well as the more complex models estimated. Both the simple and complex models still lacked the desired degree of accuracy in forecasting monthly price levels in 1980, though perhaps this should be expected when you are forecasting prices in unusual market situations

Figure 3

FORECASTING WORKSHEET

	% Change in:		Percentage Price Impact		% Price Change
Beef Q	_____	x	_____	=	_____
Pork Q	_____	x	_____	=	_____
Broiler Q	_____	x	_____	=	_____
Income	_____	x	_____	=	_____
	_____	x	_____	=	_____
			Seasonal adjustment[3/]	=	_____
			Total	=	_____

Base Period Price		100+ % Price Change		Forecast Price
_____	x	_____	=	_____

Table 3. The Percentage Change in Market Price Associated with a One Percent Change in:

	Choice Steer Price	Hog Price
Pork Production	-.3 to -.6	-2.0 to -2.3
Beef Production	-1.3 to -1.8	-.6 to -.9
Broiler Production	-	-.3 to -.7
Total Personal Income	-	+.9 to +1.1
Per Capita Real Disposable Income	+3.3 to +3.9	-

which venture beyond the limits of the observed market behavior on which the models were based. Most of these forecasting models had better forecasting results in 1981. We plan to refine these models and subject them to additional testing, while we also develop and test forecasting procedures for the key variables affecting hog and cattle market prices. Ultimately, we want to incorporate the most recent market information in relatively simple, yet useful, forecasting tools for market analysts in the livestock and meat sector.

We will continue to see evolutionary adjustments (typically very slow, but with occasional abrupt surprises) in the degree of influence of the various factors influencing commodity market prices as our economy and society continue to change. These are among the greatest challenges facing price analysts and forecasters. As market

analysts, we need to stay abreast of the changes taking place and build them into our quantitative models and forecasting procedures as quickly as possible. We need to have the most realistic tangible base for our forecasts in the form of up-to-date quantitative models; this should enhance a forecaster's credibility with clients (compared with seat of the pants forecasts), while providing a better basis for diagnosing the source of forecasting errors and prescribing changes in the future. Yet, a forecaster must remain ready to make qualitative adjustments in situations where changes in market interrelationships are becoming significant, but still are not able to be captured effectively using standard statistical procedures. We believe that the most successful price analysts and forecasters have a sound understanding of recent market interrelationships, a finely honed sensitivity to changes taking place in those relationships, the ability to translate bits and pieces of hard and soft data currently available into highly likely future price scenarios, and the capability of communicating the risks associated with actions based on alternative forecast scenarios. Hopefully, our analysis has provided some insights which might be helpful to price forecasters in better understanding and forecasting price behavior in the livestock and meat industry.

Footnotes

[1]Results from models corrected for autocorrelation indicate these flexibilities may be overestimated. However, the uncorrected models did predict more accurately (as defined by the average absolute residual).

[2]Based upon average 1962-68 prices and quantities, the direct price flexibility of beef production was -1.338 and the cross price flexibility of pork production was -.167.

[3]If year-to-year forecasts are made, the seasonal effect may be ignored. To find the percentage seasonal price adjustment between any pair of months (e.g., using known June prices, slaughter rates, etc. as the base for forecasting August prices), take the antilog of the differences in the seasonal dummy variable coefficients for the forecast and base periods. For example, if August cattle prices are to be estimated using June as the base month, the seasonal adjustment for the simple cattle forecasting model is:

antilog (-.0315 - (-.0235)) = .982 or -1.8%.

If other factors influencing price were unchanged, the August price would typically be 1.8% below June's price level due to "seasonal" factors.

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