QUANTITATIVE MODELS TO PREDICT MONTHLY PRICES OF CHOICE STEERS

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PREFACE

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CHAPTER I

INTRODUCTION

Current Situation

The cattle feeding industry has traditionally been plagued by price risk. For years cattle feeders have been subjected to vacillations of price beyond the control of any individual feeder. The structure of the beef industry and the position of the feeding activity in the marketing chain have relegated cattle feeders to the role of price takers. As such, they are subject to the whims of weather, the effects of production cycles, the collective impact of the production and marketing decisions of other cattle feeders, changing consumer tastes and preferences, and a host of other factors which influence the supply of, and demand for, the commodity which they produce.

The pattern of price volatility in the fed cattle market is by no means a recently discovered phenomenon. Although the period 1960 through 1972 displays a general upward trend in prices, several periods can be found in which the average monthly price of 900-1100 lb. Choice steers at Omaha dropped significantly within a very short time period. For example, within the five-month period from November, 1962 through March 1963, the average monthly price dropped from $29.12 per cwt. to $22.88, a decrease of over $6 per cwt. In July of 1972, Choice steer prices began a decline of almost $5 per cwt. from $38.39 in July to $33.59 in November. In addition to these large decreases in price, the entire

period is filled with numerous examples of price declines of lesser magnitude but which contributed significantly to variability of returns to the cattle feeding enterprise.

Although price variations for fed cattle have been present for many years, at no other time in recent history has this variation made itself manifest in such a startling manner as in 1973. During 1973, the price of Choice 900-1100 lb. steers at Omaha jumped from $37.75 per cwt. on January 2 to a high of $57.75 on August 13, then collapsed to $38.50 on September 24--a drop of $19.25 per cwt. in less than six weeks.

As a result of these wild gyrations in price, the risk inherent to the cattle feeding operation increased significantly. Table I provides an illustration of the potential losses to cattle feeders attributable to price uncertainty in the market for fed cattle. Losses in excess of $100 per head were commonplace during 1973.

Price volatility during 1973 was not restricted to the cash market for slaughter cattle, but was also reflected in price quotations for live cattle futures contracts. During the late summer and early fall months, market observers witnessed the most erratic and pronounced movements in the price of live cattle futures which have occurred since trading in that commodity began in late 1964. The price of the October contract ranged from a high of $60.50 on the 14th of August to a low of $37.82 on the 25th of September, a drop of $22.68 over a time period of only 30 trading days. As a further example of this extreme volatility, during the period July 23 through October 19, the October contract closed at the allowable limit price move of plus or minus $1.00 per cwt. on 35 of the 64 trading days.

TABLE I

COSTS AND RETURNS FROM CATTLE FEEDING ENTERPRISE:
AN ILLUSTRATION APPROPRIATE TO THE
OKLAHOMA PANHANDLE

Costs	
600 lbs. Choice Feeder Steer (@ average price, June, 1973, in Okla. City = $51.20/cwt.)	$307.20
Transportation to feedlot (300 mi.)	3.60
Commission ($.50/cwt.)	3.00
Sorghum Grain (2156 lbs. @ $3.67/cwt.)	78.76
Corn (18 bu. @ $2.49/bu.)	44.82
Urea (20 lbs. @ $92/ton)	.92
Cottonseed Hulls (352 lbs. @ $46.00/ton)	8.10
Alfalfa Cubes (352 lbs. @ $126.25/ton)	22.22
Labor (2 hours @ $1.77/hr.)	3.54
Management (1 hour @ 2 x labor rate)	3.54
Vet Medicine	2.46
Interest	
Feeder purchase cost x 9.2% x 180/360	14.13
Feed x 9.2% x 180/360 x 1/2	3.56
Power, Equipment, Fuel, Shelter, Depreciation	11.37
Death Loss (1.1%)	3.38
Miscellaneous & Indirect Costs	4.92
Total Cost	$515.52
Returns	
1008 lb. (1050 lb. - 4% shrink) Choice slaughter Steer (@ average price, December, 1973, in Amarillo = $40.32/cwt.)	406.43
Net Return	-$109.09 per head

The Problem

The erratic behavior of price in recent months and years has increased the already substantial degree of price risk inherent to the cattle feeding operation. This price risk acts to increase the difficulty of the marketing decision for the cattle feeder and promotes increased uncertainty in the planning process. Although a potentially valuable means of transferring price risk was created with the initiation of trade in live cattle futures on the Chicago Mercantile Exchange in 1964, surveys reveal that very few cattle feeders are utilizing this management tool.[1] Perhaps at least a partial explanation for the limited use of the live cattle futures market by cattle feeders is the fact that the futures contracts have proved to be highly vulnerable to wide swings in price and are generally inaccurate forecasters of future cash price.[2] In order for cattle feeders to better utilize the live cattle futures market and to skillfully and successfully make the marketing decisions for cattle on feed, reliable, readily available, and recurring forecasts of cash price at various points in the future are needed. At present, most cattle feeders either do not use price forecasts in their planning processes or discount the accuracy of forecasts which are used. More accurate and more creditable forecasts are needed.

Review of Literature

The ability to forecast the price of a commodity at some future point in time is one of the most diligently pursued goals in the agricultural marketing sector of our economy. Such ability to predict future prices has also been very difficult to achieve. Substantial

research time and effort has been directed toward estimating demand and supply functions for the fed beef sector of our economy; however, the vast majority of this work is based on annual or quarterly data and thus is useful only for obtaining estimates of yearly average or quarterly prices. Very little publicly available research has been aimed at explaining or anticipating monthly fluctuations in the price of fed cattle. However, some of the most relevant and recent efforts directed toward forecasting short-run supply and/or price fluctuations will be reviewed.

Hayenga and Hacklander attempted to forecast the monthly price of steers from one to six months into the future by utilizing, in a least squares linear regression framework, a set of exogenous variables whose values were projected to the time period for which the forecast of price was desired.[3] Among the projected explanatory variables were: monthly commercial pork production divided by the number of fully utilized slaughter days in the month; monthly U.S. commercial beef production divided by the number of fully utilized slaughter days in the month; U.S. total personal income, seasonally adjusted, at annual rates during the month divided by U.S. population at mid-month; percent of the total number of federally inspected cattle slaughtered consisting of cows during the month; and cold storage holdings of frozen and cured pork in the 48 states during the month immediately preceding the month for which the price forecast is desired.

The efforts of Hayenga and Hacklander resulted in the development of a model containing explanatory variables which accounted for 84 percent of the month-to-month variation in the price of Choice 900-1100 lb. steers at Chicago during the period January, 1962 to July, 1968. Forecasts of steer prices for the period July through December of 1968 were

presented in the study. Forecast errors ranged from -$1.99 per cwt. in September to +$3.65 per cwt. in October. The report stated that "Production predictions proved to be the key element reducing price prediction accuray . . . at the time the study was completed."[4]

Roddy, Hoffman, and Madsen have attempted short run price forecasts for fed cattle in a model designed to predict monthly price from two through six months into the future using least-squares, step-wise regression analysis.[5] Separate forecasting equations were estimated for each month of the year utilizing such explanatory variables as cattle and calves on feed, cold storage holdings of pork, a monthly index of prices paid by farmers in the U.S., and an index of cattle conditions in 17 western states. The final predictive equations were judged by the authors to be statistically sound and were reported to have R^2's ranging from a high of .91 in one of the two-month predictive equations for November, to a low of .13 in one of the six-month predictive equations for August. The authors cited a number of obstacles to accurate prediction. Among these were problems in obtaining reliable and accurate data which is not subject to revision. The authors also cited the necessity of approximating monthly cattle on feed numbers for the months between quarterly reports for any group of feeding states larger than the six states for which monthly reports were released by the USDA. Future research was suggested which would incorporate new explanatory variables such as federally inspected cattle slaughter, commercial slaughter, fed cattle margins, and cow-calf inventories. Different data arrangements, transformations, and regression procedures were also suggested.

Crom developed procedures for projecting the number of fed cattle to be marketed in a future quarter.[6] He utilized several lagged exogenous

variables reflecting placement and marketing motivation of cattle feeders as well as potential future supply of market weight cattle. Among the variables reflecting placement motivation were the beef-corn ratio from the previous quarter and the January 1 beef cow numbers from one year earlier. Marketings were affected by placements in previous quarters and expectations with regard to the direction of price movements.

Franzmann and Walker developed forecasting equations for the price of feeder cattle, slaughter cattle, and wholesale beef using a model which included a linear trend, a 10-year cycle, and a seasonal component.[7] In attempting to provide information on time interrelationsips among the three market levels, they found that wholesale prices generally lead feeder cattle prices, both cyclically and seasonally. The authors state that the statistical properties of the feeder and slaughter equations indicate that the model is useful for long-run planning by virtue of its ability to detect turning points in price. However, they express the opinion that the model is not of sufficient quality for decisions over short planning horizons.

Objectives

The general objective of this study is to develop an econometric forecasting model to project the price of Choice 900-110 lb. slaughter steers to be utilized by cattle feeders as an aid in making such decisions as timing of placements and marketings of cattle. This general objective can be broken down into three sub-objectives which can be stated as follows:

1. To develop an econometric model which will forecast the average monthly price of Choice 900-1100 lb. slaughter

steers from one to eight months into the future;

2. To illustrate the accuracy of the developed model as a forecasting mechanism; and
3. To infer possible uses of the model in typical decision situations.

Procedure

Sub-objective 1 will be attained through the use of a regression analysis of time series data. The average monthly price of Choice 900-1100 lb. slaughter steers will be regressed on a number of explanatory and exogenous variables representing supply and demand shifters in the market for live slaughter cattle. The group of exogenous variables tested will include variables toward which slaughter cattle price displays a lagged response as well as variables to which price responds during the current time period. For the latter group of explanatory variables, procedures will be developed to project the values of these variables to the time period for which the price forecasts are desired. Seasonal indices, trend projections and regression analyses will be employed to obtain the necessary projected values of the explanatory variables.

The attainment of sub-objective 2 will be facilitated by graphical presentations illustrating the ability of the model to forecast cash price on a monthly basis from one to eight months into the future. The graphical analysis will consist of plots of the one to eight month forecasts generated by the model in comparison to plots of the actual price.

To fulfill sub-objective 3, inferences will be drawn concerning the ability of the model to enhance the profitability of the cattle feeding

activity by providing a reliable aid to decisions involved in cattle feeding activities.

FOOTNOTES

[1]Ralph L. Tapp, "Economic Implications of Variable Weighing and Grading Practices in the Sale of Slaughter Beef" (unpub. M.S. Thesis, Oklahoma State University, 1968), and Terry Lee Dunn, "Economic Implications of Interlevel Goal Conflict and Operational Inconsistency in the Beef Marketing System: The Packer-Feeder Subsector" (unpub. M.S. Thesis, Oklahoma State University, (1970), p. 46.

[2]Wayne D. Purcell, "Do Live Cattle Futures Predict Cash Prices?" Oklahoma Current Farm Economics, Volume 42, No. 3 (September, 1969), pp. 12-18.

[3]Marvin Hayenga and Duane Hacklander, Short-Run Livestock Price Prediction Models, Michigan Agricultural Experiment Station Bulletin 25 (East Lansing, 1970), pp. 2-30.

[4]Ibid., p. 30.

[5]D. D. Rohdy, G. H. Hoffman, and A. G. Madsen, Short-Run Price Forecasting Model for Fed Cattle, Colorado Agricultural Experiment Station Technical Bulletin 108 (Fort Collins, Dec., 1969), pp. 1-38.

[6]Richard J. Crom, Marketing Aids for the Cattle Feeder, USDA Marketing Research Report No. 819 (Washington D. C., June, 1968).

[7]John R. Franzmann and Rodney L. Walker, "Trend Models of Feeder, Slaughter, and Wholesale Beef Cattle Prices," American Journal of Agricultural Economics, LIV (August, 1972), pp. 507-512.

CHAPTER II

FORMULATION OF THE SUPPLY MODELS

An important step toward the objective of predicting slaughter cattle prices on a monthly basis is the determination of an appropriate supply variable to use in the price equation. Statistics are available on a monthly basis for federally inspected cattle slaughter reported by various type and weight divisions.[1] However, although a large percentage of slaughter occurs in federally inspected plants, these figures by no means measure total slaughter. In addition, the percentages of total slaughter which is federally inspected has been increasing over time, making the series unstable and unsuitable for use in a regression analysis of time series data. Monthly information is also available on commercial beef production reported in millions of pounds (liveweight).[2] These figures account for commercial production of all beef, including both federally inspected slaughter and other commercial slaughter. However, another problem arises in that the commercial beef production figures include cow slaughter, calf slaughter, and all other slaughter of commercial beef animals, making this series inappropriate for use in a model designed to forecast the price of a specific grade and weight range of cattle.

Since the ultimate objective is the prediction of Choice slaughter steer prices, it seems reasonable to adopt the primary determinant of available live slaughter cattle supply, fed marketings, as the supply

variable. The term "fed marketings" refers to cattle sold out of feedlots for slaughter and can normally be assumed to represent those steers and heifers of market weight grading Good or better. By using fed marketings as the supply variable it is possible to circumvent the problem of finding a way to extract cow slaughter, calf slaughter, etc. from the commercial beef production series. Also, the problem of determining how close an approximation federally inspected slaughter of steer and heifer beef is of total slaughter of steer and heifer beef is eliminated.

After deciding upon the appropriate dependent variable to represent available supply of slaughter cattle, the independent variables which best explain variations in the dependent series must be specified. Among the most important determinants of fed cattle marketings within any month are the number of cattle on feed approaching "normal" market weight during the preceding month, the current price of slaughter cattle, the quantity of beef cattle available for placement during the year, and variables representing information utilized by cattle feeders in their placement decisions.

The purpose of this chapter is to identify the relevant variables, develop the data series needed, present and interpret the results of the regression analyses conducted to develop the supply models, and provide examples of the forecasting ability of the developed models.

Generation of the Dependent Series for the Regression Equations: Monthly 23-State Fed Marketings

Since the estimation of a national supply figure is required as an input for the price model, it is desirable to use fed marketings in the

23 major feeding states as reported by the USDA for the dependent series in the regression analysis. Unfortunately, the USDA collects and reports fed marketings figures for the 23 major feeding states on a quarterly basis, and reports monthly fed marketings for a subset of only seven of the 23 states.[3] Therefore, an estimation procedure had to be developed which would produce accurate estimates of monthly, 23-state fed marketings.

In attempting to estimate monthly fed marketings for use as the dependent series in the regression equations, it was hypothesized that the number of fed cattle marketed monthly from the 23 states could be estimated by assuming that the same monthly pattern of marketings existed for both the 7-state subgroup and the larger 23-state group. Since monthly figures are reported for 7-state fed marketings, it was possible to determine the manner in which quarterly marketings from the 7 states were distributed within the quarter. The 7-state monthly totals of fed marketings were expressed as a percentage of the quarterly 7-state totals.

The assumption of comparable monthly patterns is supported by the fact that quarterly marketings in the 7 selected states represent a majority of total fed marketings in the 23 states, ranging from a low of 62.77% in April of 1968 to a high of 76.49% in October of 1972. Also, the 7 states for which monthly data are reported represent a cross section of geographical areas with their attendant types of feeding operations. This reduces the probability the seasonal marketing pattern of the 7-state group is markedly different from the pattern in the 23 states.

The procedure for estimating monthly fed marketings in the 23 states can be most easily explained by enlisting the aid of Table II. In column 1 are the quarterly totals of fed marketings in the 23 reporting states. Each of these figures represents the number of fed cattle marketed during the quarter represented by the months immediately following and including the month in which the figure is recorded. For example, in April of 1968, the recorded figure of 5,657 (1,000 head) represents the total number of fed cattle marketed in the 23 selected states during the months of April, May, and June. In column 2 the number of fed cattle marketed quarterly in the 7 states is recorded in the same manner as the figures for column 1. Column 3 is obtained by dividing column 2 by column 1. This quotient provides a figure expressing 7-state quarterly fed marketings as a percentage of the 23-state quarterly total. This percentage is an indication of the importance of marketings in the 7 selected states relative to total marketings in the 23 reporting states. In addition, it gives an idea of the direction and magnitude of change in relative importance of the 7-state report over time.

The fact that fed marketings in the 7 states did represent a significant and increasing portion of total marketings lends support to the assumption that the distribution of quarterly marketings among the months within a quarter in the 23 states was the same as, or very similar to, the distribution in the 7 states. Column 4 lists the numbers of fed cattle marketed monthly in the 7 states and when divided by column 2, yields a column of figures, column 5, which express the number of fed cattle marketed monthly in the 7 states as a percentage of the quarterly 7-state totals.

TABLE II

ILLUSTRATION OF PROCEDURE EMPLOYED IN ESTIMATING
MONTHLY FED CATTLE MARKETINGS FOR 23 STATES

Year and Month	Col. 1 Number of Fed Cattle Marketed 23 States Quarterly	Col. 2 Number of Fed Cattle Marketed 7 States Quarterly	Col. 3 7 State Total Fed Marketings as a Percentage of 23-State Total Quarterly Col. 2 ÷ Col. 1	Col. 4 Number of Fed Cattle Marketed 7 States Monthly	Col. 5 Number of Fed Cattle Marketed 7 States Monthly as a Percentage of the Quarterly 7 State Total Col. 4 ÷ Col. 2	Col. 6 Estimate of Fed Cattle Marketings 23 States Col. 5 x Col. 1
	(thous.)	(thous.)		(thous.)		(thous.)
6804	5657	3551	62.77	1155	32.52	1389.7
6805				1237	34.83	1970.3
6806				1159	32.63	1845.9
6807	5583	3478	62.29	1170	33.64	1878.1
6808				1135	32.63	1821.7
6809				1173	33.72	1882.6
6810	5494	3526	64.17	1243	35.25	1936.6
6811				1129	32.01	1758.6
6812				1154	32.72	1797.6
6901	5949	3790	63.70	1319	34.80	2070.3
6902				1231	32.48	1932.2
6903				1240	32.71	1945.9
6904	5837	3687	63.16	1273	34.52	2014.9
6905				1209	32.79	1914.0
6906				1205	32.68	1907.5

TABLE II (Continued)

Year and Month	Col. 1 Number of Fed Cattle Marketed 23 States Quarterly	Col. 2 Number of Fed Cattle Marketed 7 States Quarterly	Col. 3 7 State Total Fed Marketings as a Percentage of 23-State Total Quarterly Col. 2 ÷ Col. 1	Col. 4 Number of Fed Cattle Marketed 7 States Monthly	Col. 5 Number of Fed Cattle Marketed 7 States Monthly as a Percentage of the Quarterly 7 State Total Col. 4 ÷ Col. 2	Col. 6 Estimate of Fed Cattle Marketings 23 States Col. 5 x Col. 1
	(thous.)	(thous.)		(thous.)		(thous.)
6907	6044	3820	63.20	1205	31.54	1906.3
6908				1235	32.32	1953.4
6909				1380	36.12	2183.1
6910	5953	4010	67.36	1467	36.58	2177.6
6911				1262	31.47	1873.4
6912				1281	31.94	1901.4
7001	6145	3939	64.10	1335	33.89	2082.5
7002				1229	31.20	1917.2
7003				1375	34.90	2144.6
7004	62.19	39.89	64.14	1343	33.66	2093.3
7005				1299	32.56	2024.9
7006				1347	33.76	2099.4
7007	6360	4055	63.75	1287	31.73	2018.0
7008				1360	33.53	2132.5
7009				1408	32.72	2208.2
7010	6209	4048	65.19	1430	35.32	2193.0
7011				1313	32.43	2013.6

TABLE II (Continued)

Year and Month	Col. 1 Number of Fed Cattle Marketed 23 States Quarterly	Col. 2 Number of Fed Cattle Marketed 7 States Quarterly	Col. 3 7 State Total Fed Marketings as a Percentage of 23 State Total Quarterly Col. 2 ÷ Col. 1	Col. 4 Number of Fed Cattle Marketed 7 States Monthly	Col. 5 Number of Fed Cattle Marketed 7 States Monthly as a Percentage of the Quarterly 7 State Total Col. 4 ÷ Col. 2	Col. 6 Estimate of Fed Cattle Marketings 23 States Col. 5 x Col. 1
	(thous.)	(thous.)		(thous.)		(thous.)
7012				1305	32.23	2001.2
7101	6251	3979	63.85	1369	34.40	2143.5
7102				1213	30.48	1899.2
7103				1397	35.10	2187.1
7104	6278	4069	64.81	1314	32.29	2027.2
7105				1339	32.90	2065.5
7106				1416	34.79	2184.1
7107	65.92	42.87	65.03	1382	32.23	2124.6
7108				1431	33.37	2199.8
7109				1474	34.38	2266.3
7110	6178	4634[1/]	75.00	1627	35.11	2169.1
7111				1534	33.10	2044.9
7112				1473	31.78	1963.4
7201	6443	4722	73.28	1604	33.96	2188.0
7202				1539	32.59	2099.8
7203				1579	33.43	2153.9

TABLE II (Continued)

Year and Month	Col. 1 Number of Fed Cattle Marketed 23 States Quarterly	Col. 2 Number of Fed Cattle Marketed 7 States Quarterly	Col. 3 7 State Total Fed Marketings as a Percentage of 23 State Total Quarterly Col. 2 ÷ Col. 1	Col. 4 Number of Fed Cattle Marketed 7 States Monthly	Col. 5 Number of Fed Cattle Marketed 7 States Monthly as a Percentage of the Quarterly 7 State Total Col. 4 ÷ Col. 2	Col. 6 Estimate of Fed Cattle Marketings 23 States Col. 5 x Col. 1
	(thous.)	(thous.)		(thous.)		(thous.)
7204	6727	4983	74.07	1546	31.02	2086.7
7205				1758	35.27	2372.6
7206				1679	33.69	2266.3
7207	6907	5056	73.20	1480	29.27	2021.7
7208				1782	35.24	2432.0
7209				1794	35.48	2450.6
7210	6772	5180	76.49	1847	35.65	2414.2
7211				1737	33.49	2267.9
7212				1598	30.84	2088.5
7301	6651	4957	74.53	1739	35.08	2333.2
7302				1571	31.69	2107.2
7303				1623	32.74	2177.5
7304	6302	4701	74.59	1440	30.63	1930.3

The percentages in column 5 therefore represent the monthly pattern of the quarterly totals of fed marketings. It has been assumed the monthly pattern of marketings within any one quarter will be the same or similar for both the 7-state subgroup and the 23-state group. The percentages in column 5 may then be multiplied by the quarterly numbers of fed cattle marketed in the 23 states, found in column 1, to arrive at the desired estimate of monthly fed cattle marketings in the 23 selected states, column 6.

Exogenous Variables Measuring the Number of Beef Animals Available for Feeding and Slaughter

Cattle on Feed

In attempting to determine fed marketings for any month, it is necessary to first determine the available supply of cattle that will be of normal market weight during the month in question. The available supply of market weight cattle in some future month is primarily determined by the number of cattle on feed in the present month in a particular weight and sex category. The appropriate category of cattle on feed to use for estimation of available supply is determined by the length of the feeding period remaining between the present time and the month for which the supply figure is desired, the average daily rate of gain, and the normal market weight.

The length of the feeding period remaining cannot be pinpointed to a specific number of days due to the fact that marketings for the forecast month can occur on any day within the month, leaving a possible variation of approximately 30 days. Therefore, a range was assumed for

each forecast interval within which the number of days on feed could vary a maximum of 30. Since the figures in the USDA's cattle on feed report represent number of cattle on feed as of the first day of the month in which the report is issued, the logical starting point for determining days on feed for each forecast interval is at the beginning of time period T (present month). To the 30 days in month T, we add an additional 30 days for each month into the future for which a forecast is desired. A lower bound is created by ending the feeding period on the first day of the forecast month, and an upper bound by extending the period through the entire month.

Since the projection of a national supply figure is the object of the supply model, the average market weight of Choice steers at Omaha was accepted as a typical market weight which would reasonably represent the average weight of fed steers slaughtered nationally. A weighted average of Choice steers marketed at Omaha during the period 1968 through 1973 was calculated and the result, approximately 1125 lbs., was used in the calculations. The corresponding market weight for heifers was estimated to be 925 lbs.[4] For example, the upper bound of the feeding range for period T+1 is found by adding one 30-day period to the original 30 days in period T. The lower bound is determined by ending the feeding period at the beginning of T+1, therefore, including only the original 30 days from period T. The range for T+1 would then be 30 to 60 days. The feeding period ranges for each of the forecast intervals can be found in Table III.

In arriving at a figure for rate of gain per day, a problem arises due to the wide diversity in rates of gain caused by differences in types of cattle fed, sex, ration, weather conditions, etc. Therefore, it was

TABLE III

ESTIMATION PROCEDURE FOR DETERMINING THE APPLICABLE CATTLE ON FEED (C.O.F.) WEIGHT CATEGORY FOR EACH OF THE PREDICTION INTERVALS T-1 THROUGH T-8

Prediction Interval	Number of Days on Feed	Rate of Gain Range (lbs/day)	Total Pounds of Gain for the Period	Normal Market Weight		Beginning of Period Weight Range		Applicable C.O.F. Category	
				Steers	Heifers	Steers	Heifers	Steers	Heifers
	60	3.3	198	1125	925	927-1065			
T + 1	30	2.0	60				727-865	900-1099	700-899
	90	3.3	297			628-1005		700-899	500-699
T + 2	60	2.0	120				628-805	900-1099	700-899
	120	3.3	396			729-945		700-899	500-699
T + 3	90	2.0	180				529-745	900-1099	700-899
	150	3.3	495			630-885		500-699	<500
T + 4	120	2.0	240				455-710	700-899	500-699
	180	3.3	594			531-825		500-699	<500
T + 5	150	2.0	300				331-625	700-899	500-699
	210	3.3	693			432-765		<500 500-699	<500
T + 6	180	2.0	360				232-565	700-899	500-699
	240	3.3	792			333-705		<500	<500
T + 7	210	2.0	420				133-505	500-699	
	270	3.3	891			234-645		<500	<500
T + 8	240	2.0	480				34-445	500-699	

felt that using a range of rates would provide more accurate information. The rate of gain used in the calculations ranged from a lower bound of 2.0 lbs. per day to an upper bound of 3.3 lbs. per day. By using such a wide range, it was felt that virtually all types of cattle and levels of feeding efficiency would be included.

The determination of an acceptable figure to use for "normal" market weight presented yet another problem. The weight of fat cattle marketed varies according to geographic region, season, sex and type of cattle, etc.

Calculations made to arrive at the appropriate weight categories for the various predictive intervals, using the above specified time periods, rates of gain, and market weights are shown in Table III.

Immediately after deciding upon the appropriate weight and sex categories to apply to the time period for which the fed marketings information is desired, another problem in encountered. The 23-state cattle on feed report, with numbers broken down by weight and sex, is issued quarterly. In order to predict monthly fed marketings, some method had to be devised to allocate the quarterly numbers on feed, in their various weight and sex categories, across the interim months. In order to accomplish this task, it was assumed that the monthly 7-state report issued by the USDA was a fairly representative sample of feeding activity in the 23 states, and could be used as a base from which to project monthly totals on feed in each weight and sex category for the entire 23-state area. This assumption is based on the fact that the numbers on feed in the 7 selected states have represented a steadily increasing percentage of the 23-state total since the report's inception,

rising from 57.95 percent in April of 1968 to 75.6 percent in October of 1973.

The procedure adhered to in estimating monthly cattle on feed in each of the weight and sex categories for use in the regression analysis can be most easily understood by referring to a sample of the original worksheet reproduced in Table IV. Using figures representing quarterly totals of cattle on feed reported for both the 23-states (column 1) and the 7-states (column 2), the 7-state total as a percentage of the 23-state total was calculated. The results of these calculations are listed in column 3 of the table. Next the monthly 7-state cattle on feed reports were employed in conjunction with the previously computed percentages of column 3 to arrive at a monthly estimate of cattle on feed in the 23 states for the interim months of each quarter. This was accomplished by dividing the monthly number on feed in the 7 states by the percentage of the 23-state quarterly total which the 7 state quarterly total represented (column 4 ÷ column 3). The resulting monthly estimates of cattle on feed in the 23 states are presented in column 5. It was then necessary to collect, from the quarterly 23-state reports, the numbers on feed at the beginning of each quarter in each weight and sex category which the USDA reports. These figures can be found printed in rows 1 and 4, columns 15 through 23 of the table. Dividing each of these numbers by the 23-state total of cattle on feed in the corresponding quarter will yield a set of numbers representing the percentage of the total number of cattle on feed attributable to each weight-sex category quarterly. These percentages can be found in rows 1 and 4, columns 6 through 14. Since monthly information on weight-sex breakdowns is supplied by neither the 7-state nor the 23-state

TABLE IV

ILLUSTRATION OF PROCEDURE USED IN ESTIMATING MONTHLY CATTLE ON FEED BY WEIGHT AND SEX CATEGORIES

Month	Col. 1 COF Quarterly Totals 23 States	Col. 2 COF Quarterly Totals 7 States	Col. 3 7-State COF as Percent of 23-State Total Col. 2 ÷ Col. 1	Col. 4 COF Monthly Totals 7 States	Col. 5 Estimated Total COF 23 States Monthly Col. 4 ÷ Col. 3
Jan.	13,920	9,943	71.43	9,943	13,919,900
Feb.			71.43	10,060	14,083,700
Mar.			71.43	9,698	13,576,900
Apr.	13,414	9,637	71.84	9,637	13,414,500

TABLE IV (Continued)

Month	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10	Col. 11	Col. 12	Col. 13	Col. 14
	Percent of Total Number of COF Attributable to Each Category--Monthly								
	Steers					Heifers			
	<500	500-700	700-900	900-1100	>1100	<500	500-700	700-900	900-1100
Jan.	7.69	17.95	22.67	18.37	4.56	6.35	9.77	8.54	3.59
Feb.	6.59	18.71	22.75	18.82	4.31	5.58	10.73	8.67	3.35
Mar.	5.48	19.46	22.82	19.27	4.05	4.80	11.70	8.80	3.12
Apr.	4.38	20.22	22.90	19.72	3.80	4.03	12.66	8.93	2.88

TABLE IV (Continued)

Month	Col. 15	Col. 16	Col. 17	Col. 18	Col. 19	Col. 20	Col. 21	Col. 22	Col. 23
	Estimated Number of COF in Each Category--Monthly								
	Steers (thous.)					Heifers			
	<500	500-700	700-900	900-1100	>1100	<500	500-700	700-900	900-1100
Jan.	1,071.0	2,499.0	3,156.0	2,558.0	635.0	885.0	1,360.0	1,190.0	500.0
Feb.	928.1	2,635.1	3,204.0	2,650.6	607.0	785.9	1,511.2	1,221.1	471.8
Mar.	744.0	2,642.1	3,098.3	2,616.3	549.9	651.7	1,588.5	1,194.8	423.6
Apr.	588.0	2,713.0	3,073.0	2,646.0	511.0	541.0	1,699.0	1,199.0	387.0

report, linear interpolation was used to estimate the percentage of the total attributable to each weight-sex category in the interim between quarterly reports. These interpolated percentages are presented in rows 2 and 3, columns 6 through 14. Multiplying the percentage of the total number of cattle on feed attributable to a particular weight-sex category for each month times the estimated monthly 23-state totals of cattle on feed, in column 5, yields an estimate of the number of cattle on feed in each weight-sex category monthly (columns 15 through 23). From these monthly estimates of the number in each weight-sex category can be selected the appropriate category or categories to be used in the fed marketings projections for each of the forecast intervals.

Inventory of Beef Calves

Given that it is necessary to determine the number of market weight animals available for slaughter through the use of cattle on feed information, it is also necessary to incorporate a measure of the number of young beef animals which will be available for placement in feedlots within a specified time period. The January 1 Beef Calf Inventory figures as reported by the Statistical Reporting Service of the USDA proved useful for this purpose. The series measures the numbers of heifers, steers, and bulls under 500 lbs., plus steers 500 lbs. and over. By eliminating heifers for replacement purposes and bulls over 500 lbs. from the inventory, the series yields a figure which can be roughly interpreted as the sum of cattle currently on feed plus the available supplies of feeder cattle within a calendar year. The inclusion of this data series should have the effect of setting the general level of fed marketings within a year, and when used in conjunction with the cattle

on feed information, should provide an estimate of supplies of feeder animals available for placement. This should be particularly helpful in the more distant predictions for which the cattle on feed information alone would not be expected to have an appreciable impact.

Explanatory Variables Reflecting the Degree of Placement and Marketing Motivation of Feeders at Various Points in Time

The average price of Choice 900-1100 lb. steers at Omaha for the current month was chosen as an explanatory variable to aid in predicting the behavior of cattle feeders. The expected response of feeders to anticipated increases in price in future time periods is increases in placements and, with some time lag, an increase in marketings. Feeders may view current prices as an indication of what prices will be in the near future. For this reason, the current price of fed cattle was selected as an explanatory variable and tested for significance in each of the models.

The ratio of the price of Choice 900-1100 lb. steers at Omaha to the price of Choice 600-700 lb. feeder steers at Oklahoma City was used as a variable to aid in predicting the behavior of cattle feeders with regard to the replacement decision. The underlying assumption is that cattle feeders view the price of feeder animals relative to the price of the finished slaughter animal in the current time period as an indication of future profitability of the cattle feeding enterprise. As the ratio increases, fed marketings could be expected to increase in the near future as finished cattle are replaced by lighter feeder animals. In the more distant months, the slaughter price-feeder price ratio could

also be expected to have a significant impact as placement decisions made in the current month begin to reveal themselves in the form of increased marketings of slaughter cattle.

Another explanatory variable utilized to indicate change in placements of cattle on feed was the ratio of the price, in dollars per cwt., of Choice 900-1100 lb. steers at Omaha to the price, in dollars per bushel, of number two yellow corn at Omaha. This ratio represents the number of bushels of corn equivalent in value to one hundred lbs. of live steer and provides an indication of the profitability of the cattle feeding activity. As an indication of profitability, this ratio could be expected to have a significant positive impact on placements and therefore on marketings in future time periods. When used concurrently, the slaughter price-feeder price ratio and beef-corn ratio should represent the impact on fed marketings of the cost-benefit ratios of the two primary components of the feeding activity--feeder cattle and grain.

The ratio of the current month's average price of Choice 900-1100 lb. steers at Omaha to the previous month's price for the same class of steers was used as an indicator of the trend in prices for fed cattle. It was expected that the ratio would reflect feeder's expectations of future price and thus be an indicator of the trend in placements and marketings. An increase in the ratio could be expected to have a negative impact in the immediate future on fed marketings as cattle are "held" during rising prices. Given the passage of one to two months, the impact should be positive. For a planning horizon of 4-6 months, the impact could be negative since holding of cattle during rising prices postpones the placing of light cattle which would be marketed in 4-6 months.

Variables Utilized to Account for the Impact of Seasonally Recurring Changes in Marketing Patterns

Although seasonality in marketing of fed cattle has become less of a factor in recent years as the seasonal variations of both marketings and price have become less pronounced, the seasonal component is still reported to contribute as much as 68 percent to the month-to-month variation in Choice slaughter steer price.[5] Due to the reported importance of seasonality, monthly dummy variables were used as intercept shifters to account for the various seasonally recurring factors which may influence the monthly flow of cattle to market.

Results of the Fed Marketings Regressions

The series reflecting the number of fed cattle marketed monthly in the 23 major feeding states was regressed (using least squares regression) on the previously mentioned explanatory variables. The explanatory variables include the number of beef animals available for feeding and slaughter within a specified time period used concurrently with those variables reflecting the level of placements and marketing motivation of cattle feeders at various points in time. All of the explanatory variables tested were variables to which fed marketings could be expected to display a lagged response. With this in mind, the previously specified procedure to determine the sex and weight categories of cattle on feed most likely to affect fed marketings at each of the predictive intervals was undertaken, and the resulting categories tested for significance in the appropriate models. Simultaneously, each

of the variables reflecting marketing and placement motivation, as well as combinations of variables, were tested in each of the models to determine their impact on fed marketings. A list of variable notation is presented in Table V. The results of the testing procedure and the variables finally selected are presented in Table VI. Variables were selected on the basis of economic justification and statistical significance.

In some cases, variables were included whose statistical significance appears questionable. One such case is the set of monthly dummy variables included in each of the eight predictive models. Often, one or two of the 11 dummy variables display poor test statistics. However, the inclusion of this set of variables was judged to be essential because of the importance of seasonality in fed marketings. Also, in most instances, the variable displaying the poor test statistic was found to be highly correlated with one or more of the other explanatory variables. Other instances can be found in which variables of questionable statistical significance were not deleted from the equation because they were found to be highly correlated with one or more of the other explanatory variables within the same equation. It was felt that the impact of these variables was accounted for in the parameter estimates of the variables with which it was so highly correlated. In the development of models such as these, whose only object is to accurately forecast the dependent variable, the precision with which individual parameters are estimated is of little importance as long as a measurement of the impact of each of the economically relevant variables is contained within the equation as a whole.

TABLE V

DEFINITION OF VARIABLES IN THE SUPPLY REGRESSIONS

FEDMKG	= Monthly, 23-state, fed marketings (Dependent variable for the Regression Equations).
D2-D12	= Monthly dummy variables included in the equation to allow the level of the regression line to shift from month to month due to otherwise unspecified seasonal factors. D2 represents the month of February; D3 represents March; D4, April, etc. The month of January was denied representation by a dummy variable in order to avoid the statistical problem of singularity in the estimation procedure. Thus, the seasonal effect of January will be in the measurement of the intercept term.
EST9-11	= Estimated number of steers on feed monthly in the 23 major feeding states, as reported by the USDA, in the 900-1099 lb. weight class.
SUMSTR3	= Sum of the estimated number of steers on feed monthly in the 23 major feeding states in the 700-899 lb. and 900-1099 lb. weight classes.
SUMSTR4	= Sum of the estimated number of steers on feed monthly in the 23 major feeding states in the 500-699 lb. and 700-899 lb. weight classes.
SUMSTR2	= Sum of the estimated number of steers on feed monthly in the 23 major feeding states in the <500 lb., 500-699 lb., and 700-899 lb. weight classes.
SUMSTR5	= Sum of the estimated number of steers on feed monthly in the 23 major feeding states in the <500 lb. and 500-699 lb. weight classes.
HEST7-9	= Estimated number of heifers on feed monthly in the 23 major feeding states in the 700-899 lb. weight class.
SUMHER3	= Sum of the estimated number of heifers on feed monthly in the 23 major feeding states in the 500-699 lb. and 700-899 lb. weight classes.
SUMHER4	= Sum of the estimated number of heifers on feed monthly in the 23 major feeding states in the <500 lb. and 500-699 lb. weight classes.
HEST5	= Estimated number of heifers on feed monthly in the 23 major feeding states in the <500 lb. weight class.

TABLE V (Continued)

INV-1	= January 1 Beef Calf Inventory which measures the number of heifers, steers, and bulls under 500 lbs., plus the number of steers 500 lbs. and over.
OM-OKC	= Ratio of the price of Choice 900-1100 lb. steers at Omaha to the price of Choice 600-700 lb. feeder steers at Oklahoma City.
BEEF-COR	= Number of bushels of corn equivalent in value to one hundred pounds of live steer measured by the ratio of the price, in dollars per cwt., of Choice 900-1100 lb. steers at Omaha to the price, in dollars per bushel, of number 2 yellow corn at Omaha.
PRCRAT	= Ratio of the current month's average price of Choice 900-1100 lb. steers at Omaha to the previous month's price of Choice 900-1100 lb. steers at Omaha.

TABLE VI

THE ESTIMATED REGRESSION EQUATIONS FOR FED MARKETINGS[a]

Dependent Variable	Intercept	Monthly Dummy Variables				
		D2	D3	D4	D5	D6
FEDMKG T+1	198.426 (166.155)	-205.688 (49.326)	- 84.812 (48.897)	- 89.527 (53.755)	- 32.454 (55.687)	-121.317 (55.986)
FEDMKG T+2	164.235 (168.960)	-164.055 (45.775)	-103.318 (49.199)	-192.275 (63.043)	-147.392 (75.713)	-142.647 (89.836)
FEDMKG T+3	-612.919 (401.245	-217.264 (43.802)	- 78.421 (44.883)	-208.317 (52.943)	-241.623 (65.113)	-212.473 (77.087)
FEDMKG T+4	-129.392 (422.322)	-181.863 (47.759	-174.598 (61.683)	-316.924 (87.011)	-499.727 (119.650)	-507.753 (122.279)
FEDMKG T+5	94.347 (449.481	-154.362 (49.747	- 28.465 (51.617)	-154.207 (68.774)	-187.264 (92.678)	-339.153 (126.134)
FEDMKG T+6	587.696 (191.005)	-166.298 (52.575)	- 29.561 (52.987)	- 63.229 (56.295)	- 49.406 (78.988)	- 49.560 (118.229)
FEDMKG T+7	918.115 (404.254)	-231.054 (59.747)	- 82.124 (64.039)	-126.167 (62.099)	- 53.067 (59.145)	68.433 (85.816)
FEDMKG T+8	1468.330 (374.247)	-205.663 (51.025)	-133.061 (70.021)	-169.446 (73.519)	-125.968 (69.384)	- 64.230 (61.580)

TABLE VI (Continued)

Dependent Variable	Monthly Dummy Variables					
	D7	D8	D9	D10	D11	D12
FEDMKG T+1	-312.941 (85.136	-240.941 (112.869)	- 69.633 (80.680)	- 39.853 (58.279)	-205.421 (49.187)	-251.199 (49.490)
FEDMKG T+2	-240.845 (77.224)	-186.750 (70.473)	- 62.613 (60.042)	.752 (50.194)	-139.507 (46.656)	-171.269 (46.129)
FEDMKG T+3	-333.543 (91.113)	-234.061 (79.819)	-214.419 (75.036)	-191-053 (64.636)	-266.726 (51.802)	-245.948 (44.925)
FEDMKG T+4	-574.343 (155.793)	-408.505 (113.202)	-241.509 (82.528)	-175.706 (64.467)	-222.355 (51.817)	-231.381 (48.180)
FEDMKG T+5	-460.701 (128.176)	-276.404 (121.564)	-178.518 (118.598)	-168.383 (85.846)	-301.543 (64.888)	-243.673 (50.336)
FEDMKG T+6	-227.228 (181.553)	- 82.054 (180.493)	17.512 (167.187)	- 16.595 (166.713)	-206.593 (118.617)	-238.009 (80.563)
FEDMKG T+7	73.784 (139.860)	272.174 (213.545)	309.917 (162.235)	185.232 (108.918)	- 70.590 (73.634)	-172.775 (54.822)
FEDMKG T+8	- 36.910 (69.305)	250.427 (114.114)	462.543 (183.728)	303.450 (133.977)	- 25.244 (84.239)	-183.848 (55.578)

TABLE VI (Continued)

Dependent Variable	Cattle on Feed Weight Groupings								
	Steers					Heifers			
	EST9-11	SUMSTR3	SUMSTR4	SUMSTR2	SUMSTR5	HEST7-9	SUMHFR3	SUMHFR4	HEST5
FEDMKG T+1	.102 (.128)					.525 (.244)			
FEDMKG T+2		.098 (.070)					.272 (.136)		
FEDMKG T+3		.124 (.070)					.355 (.130)		
FEDMKG T+4			.026 (.066)					.460 (.170)	
FEDMKG T+5			.057 (.070)					.284 (.178)	
FEDMKG T+6				.009 (.044)				.087 (.227)	
FEDMKG T+7					-.030 (.058)				-.463 (.386)
FEDMKG T+8					.032 (.054)				-.711 (.360)

TABLE VI (Continued)

Dependent Variable	INV-1	OM-OKC	BEEF-COR	PRCRAT	R^2	Durbin-Watson
FEDMKG T+1	.025 (.006)				.83	2.05
FEDMKG T+2	.020 (.007)				.85	2.19
FEDMKG T+3	.019 (.006)	562.280 (258.707)			.87	2.29
FEDMKG T+4	.027 (.007)	438.378 (281.645)			.84	2.20
FEDMKG T+5	.025 (.007)	362.099 (299.649)			.82	2.00
FEDMKG T+6	.027 (.007)		8.576 (6.952)		.81	1.92
FEDMKG T+7	.036 (.006)		16.054 (5.510)	-503.151 (358.169)	.82	2.07
FEDMKG T+8	.034 (.006)		17.683 (5.129)	-1011.526 (333.364)	.83	2.00

[a]The numbers in parentheses refer to the standard error of the estimated coefficients.

One-Month Predictive Equations

The model designed to forecast fed marketings one month into the future utilized the estimated number of 900-1099 lb. steers and 700-899 lb. heifers on feed monthly, the inventory of beef calves on January 1 of the year containing the forecast base month (month T), and monthly dummy variables to explain otherwise unexplained monthly variations in fed marketings during the observation period, April, 1968 through March, 1973. The price of Choice 900-1099 lb. steers at Omaha in the current month was originally used as an input in the one month predictive equation in the hope that it would help explain short term fluctuations in marketings due to price expectations for the month immediately following. However, this variable made only a negligible contribution to R^2 and was found to be statistically insignificant. Given the added concern over the economic importance of the variable over the very short time span, it was deleted from the model. The rather high standard error and poor test statistics (t - .79; partial F value - .64) for the variable representing steers on feed in the 900-1099 lb. category could easily be the result of the degree of correlation between this variable and the beef calf inventory variable (r - .74), and/or the lesser degree of correlation with the variable representing heifers on feed in the 700-899 lb. class (r = .28). Due to this correlation, it is likely that the coefficients for the inventory variable and/or the 700-899 lb. heifers on feed variable could contain a measure of the impact of the steers on feed numbers.

In order to better understand the ability of the model to estimate the number of fed cattle marketings one month into the future, backcasts

were made for the period June, 1968 through April, 1973. A forecast was made using April, 1973 as the base month and projecting to May, 1973, one month out of the observation period. A graphical presentation of both the backcasts and forecast can be found in Figure 1. The time scale on the horizontal axis has the value "0" for April, 1968, "1" for May, 1968, etc. The first set of actual and predicted values is for June, 1968 (scale value of 2) and the last set for May, 1973 (scale value of 61). The prediction for May, 1973 is the only forecast or predicted value outside the time space of the data set.

Two-Month Predictive Equations

The two month predictive model was constructed using the sum of steers on feed in the 700-899 lb. and 900-1099 lb. categories, the sum of heifers on feed in the 500-699 lb. and 700-899 lb. categories, and the January 1 beef calf inventory in conjunction with monthly dummy variables. The beef calf inventory and heifers on feed variables were both found to be significant at the .05 level or better. The variable representing steers on feed was found to be significant at only the .17 level, but since it was found to be correlated with both the heifers on feed variable ($r = .53$) and beef calf inventory variable ($r = .78$) it was assumed that the remaining impact of the variable was measured in the inventory and/or heifers on feed variable.

Results of the final model indicated that variations in the explanatory variables selected accounted for approximately 85% of the month-to month variation in fed marketings. Graphical presentations of backcasts over the observation period and two month forecasts projecting fed marketings in May and June of 1973 on the basis of information

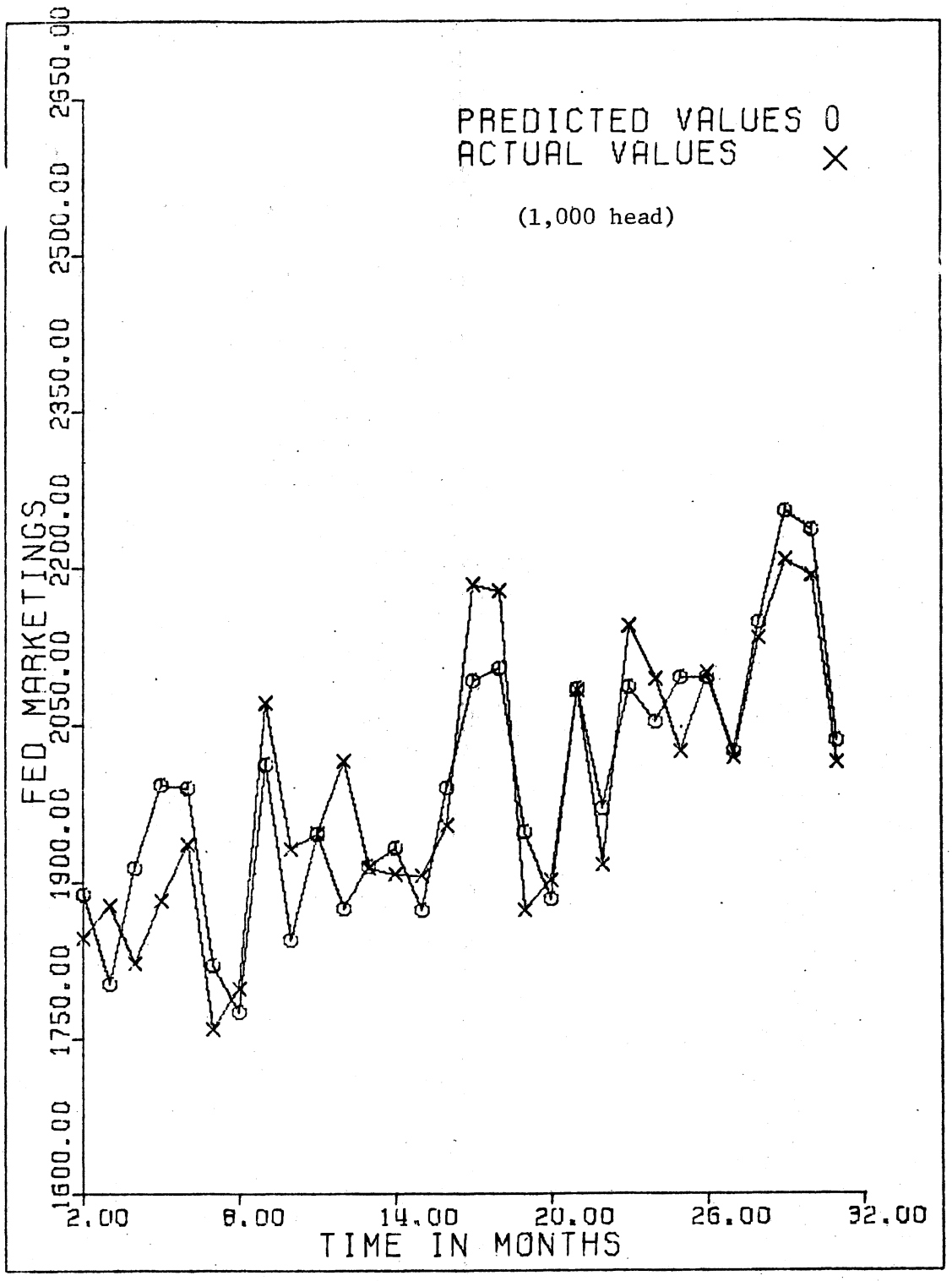

Figure 1. Backcasts, Forecasts and Actual Monthly Fed Marketings, One-Month Model.

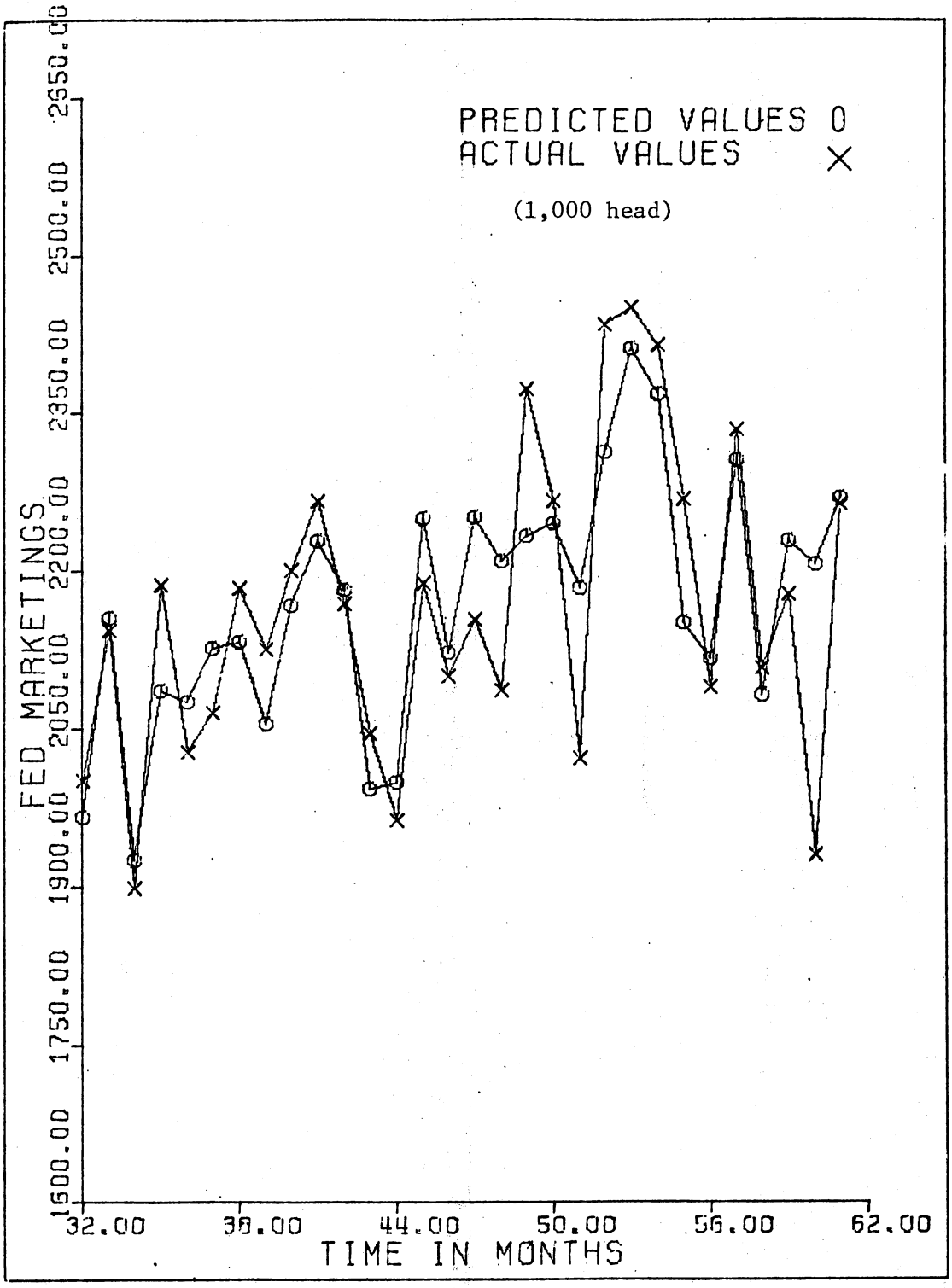

Figure 1. (Continued)

obtained in March and April of the same year, found in Figure 2 should aid in understanding the model's predictive ability. In Figure 2 it can be seen that the forecast overestimated fed marketings in June, 1973 (time scale value of 61) by 217,320 head. This overestimation can be at least partially explained by the disruption of normal marketing patterns precipitated by the anticipation of government intervention prior to March, 1973 and afterward by the effect of the price freeze on beef instituted on March 27, 1973.

Three-Month Predictive Equations

After testing several variables and combinations of variables for explanatory power it was determined that the model which displayed the greatest predictive ability from among those tested was one which consisted of variables representing the sum of steers on feed in the 700-899 lb. and 900-1099 lb. categories, the sum of heifers on feed in the 500-699 lb. and 700-899 lb. categories, the ratio of the price of Choice 900-1100 lb. steers at Omaha to the price of Choice 600-700 lb. feeder steers at Oklahoma City, and the January 1 inventory of beef calves used concurrently with the monthly dummy variables which acted to shift the level of the regression line due to seasonality. All of the explanatory variables, including the monthly dummy variables, were deemed significant at the .10 level or better.

The results of the regressions for the three-month model indicated that variations in the independent variables explained approximately 87% of the variation in the dependent series, monthly fed marketings. Graphical presentations of backcasts over the observation period and three-month forecasts projecting fed marketings in May, June, and July

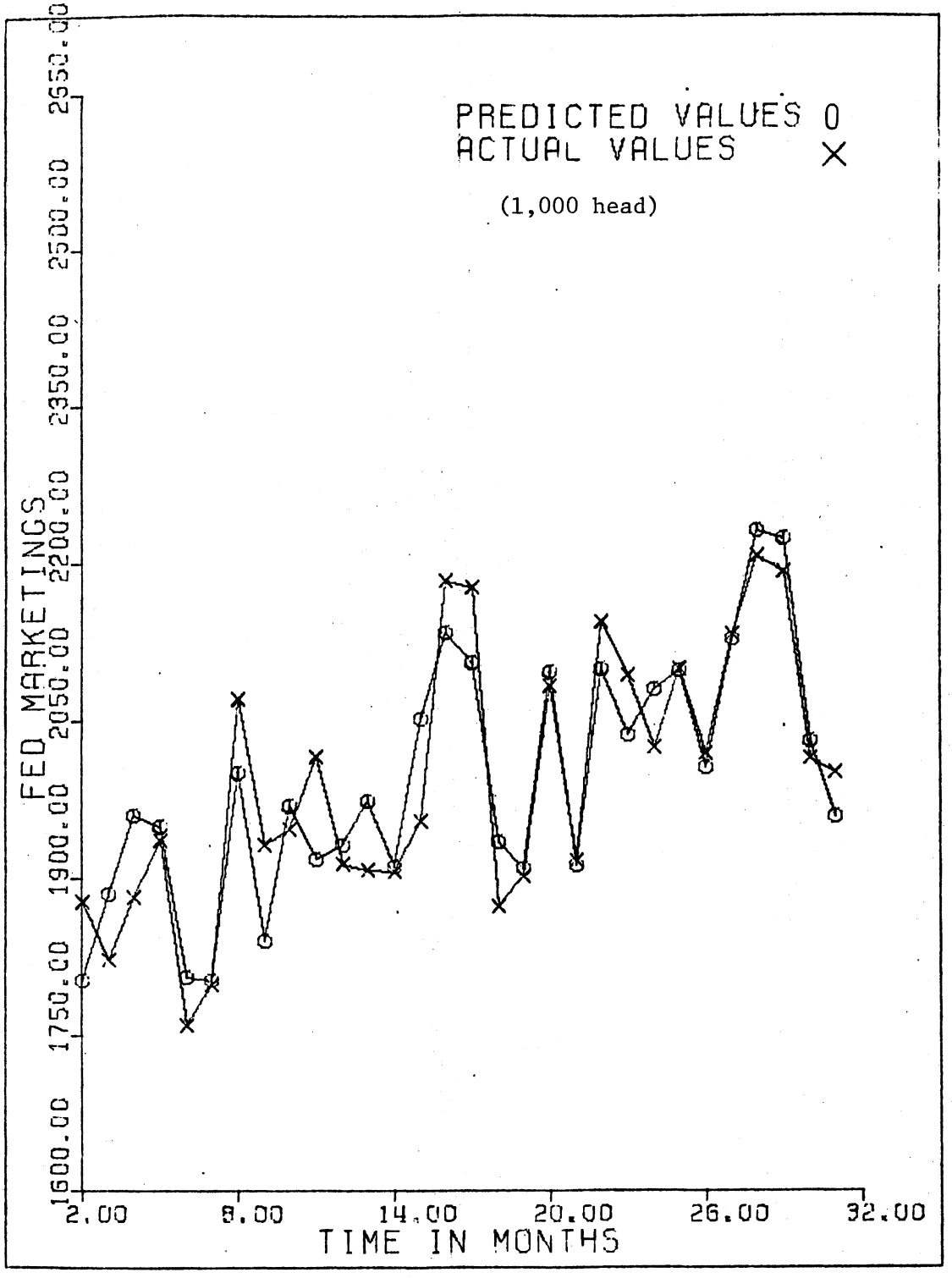

Figure 2. Backcasts, Forecasts and Actual Monthly Fed Marketings, Two-Month Model.

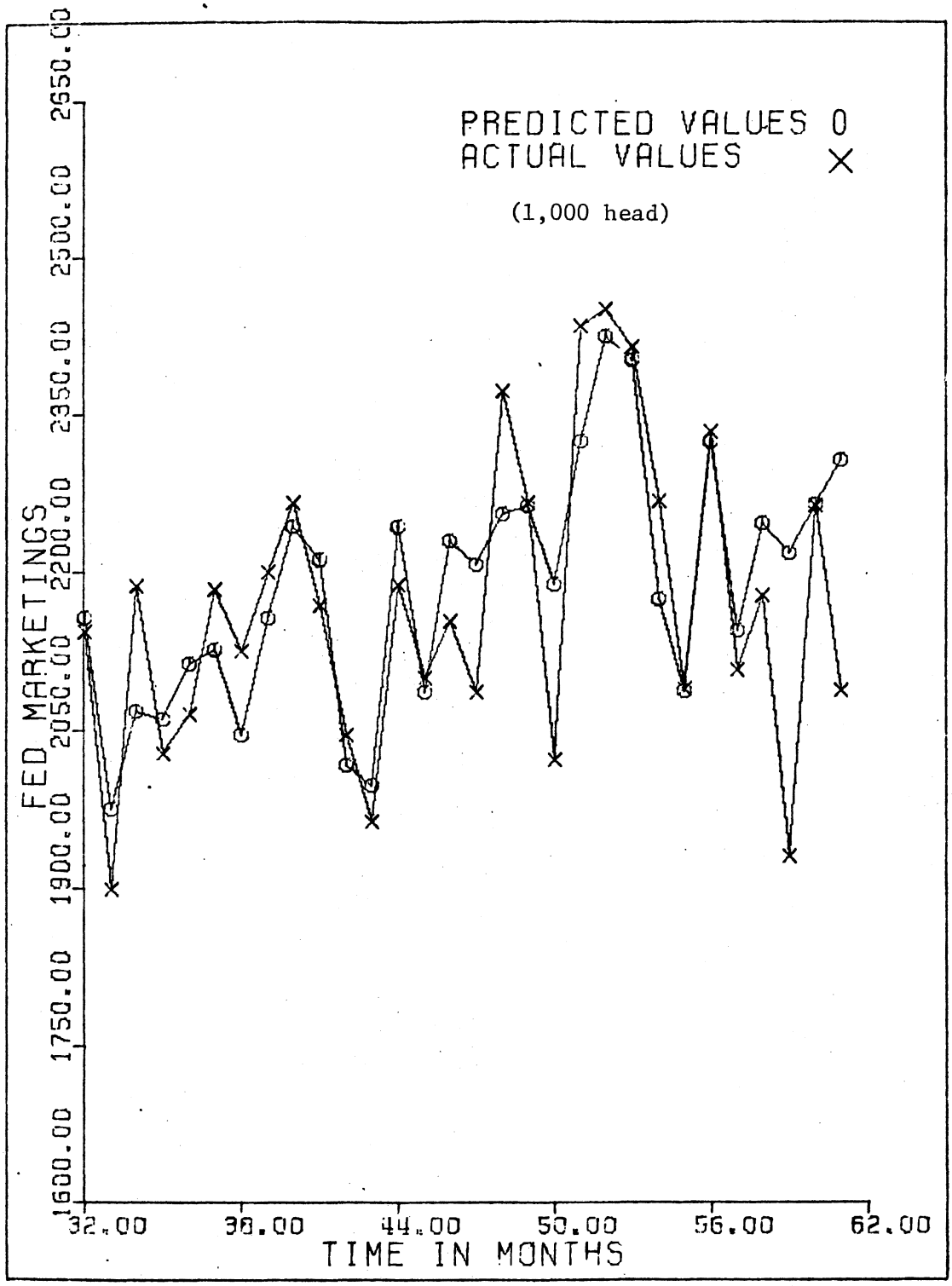

Figure 2. (Continued)

of 1973 (time-scale values 59, 60 and 61 respectively) based on information collected in February, March, and April respectively, can be found in Figure 3.

Four-Month Predictive Equations

The explanatory variables composing the four-month predictive model include the sum of steers on feed in the 500-699 lb. and 700-899 lb. categories, the sum of heifers on feed in the 500 lb. and under category plus the 500-699 lb. category, the ratio of Choice 900-1100 lb. steer price at Omaha to the price of Choice 600-700 lb. feeder steers at Oklahoma City, the January 1 inventory of beef calves, and monthly dummy variables. All of the explanatory variables were found to be statistically significant at the .05 level or better with the exception of the steers on feed variable and variable representing the slaughter price to feeder price ratio. In the case of the steers on feed variable, it was found to be correlated with the inventory variable ($r = .67$), the slaughter price to feeder price ratio ($r = -.35$), and the heifers on feed variable ($r = .81$). The slaughter steer price to feeder price ratio was found to be correlated with both the inventory ($r = -.58$) and steers on feed ($r = -.35$) variables. Because of the degree of multicollinearily observed neither of these statistically marginal variables was dropped from the equation. Approximately 84% of the variation in the dependent series was explained by variations in the independent variables which made up the four-month predictive model.

Figure 4 contains plots of backcasts made over the observation period, as well as four month forecasts projecting the number of fed cattle marketed in May, June, July, and August (time scale values 58

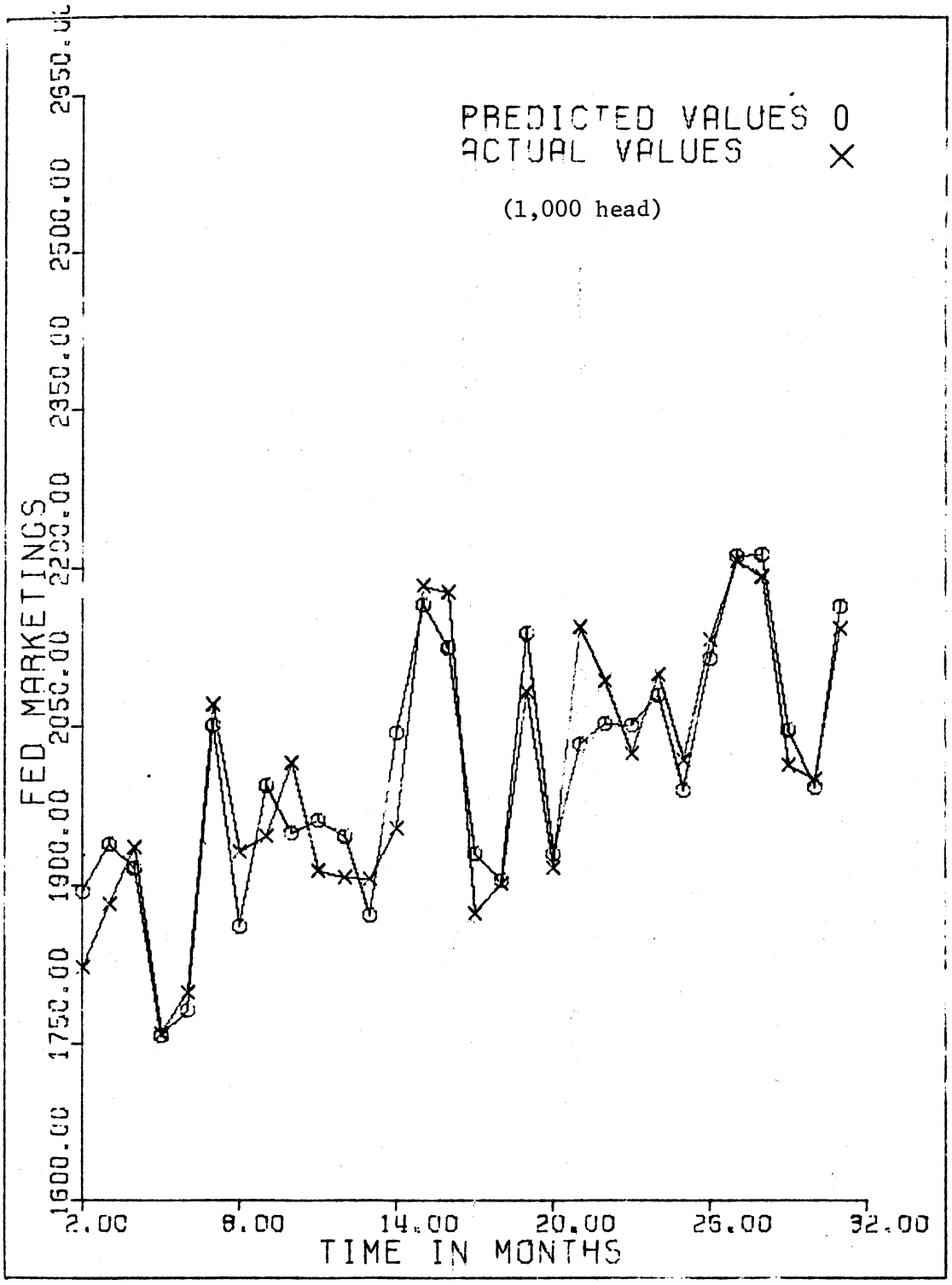

Figure 3. Backcasts, Forecasts and Actual Monthly Fed Marketings, Three-Month Model.

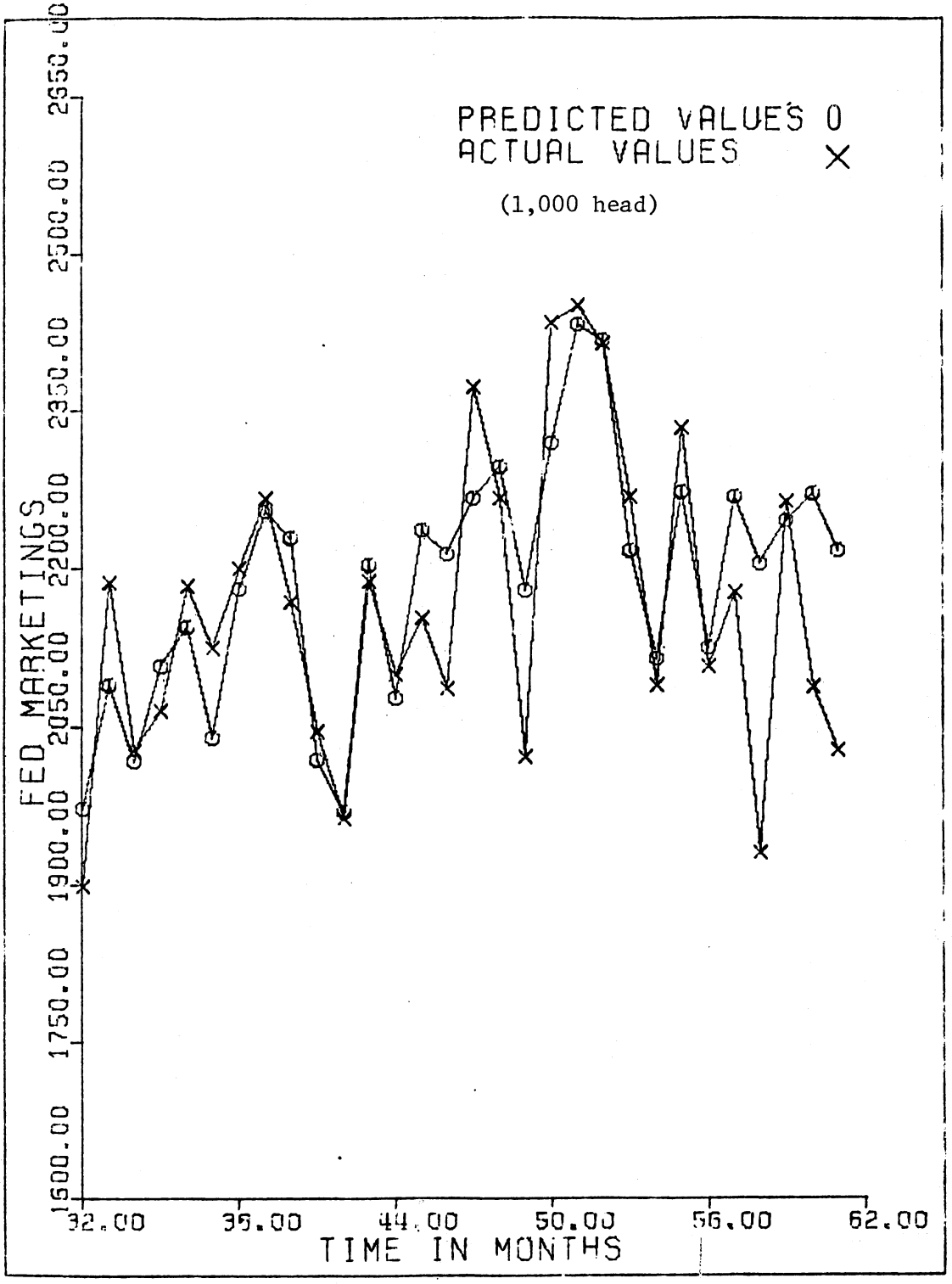

Figure 3. (Continued)

through 61) based on information available in January, February, March, and April respectively. Predicted marketings for June through August were a great deal above actual marketings for that time period due, in part, to the abnormally low level of marketings as feeders awaited the removal of price ceilings on beef.

Five-Month Predictive Equations

The model built for the purpose of forecasting fed marketings five months in advance combined the effect of the following explanatory variables to explain approximately 82 percent of the month-to-month variations in fed marketings: the sum of steers on feed in the 500-699 lb. and 700-899 lb. categories, the sum of heifers on feed in the 500 lb. and under category plus those in the 500-699 lb. category, the ratio of the price of Choice 900-1100 lb. steers at Omaha to the price of Choice 600-700 lb. feeder steers at Oklahoma City, the number of beef calves in the U.S. on January 1, and monthly dummy variables utilized to allow seasonal shifts in the level of the regression line. Five out of the total of 15 explanatory variables were not deemed significant at the .10 level or better. However, in each case the variables were found to be correlated with one or more of the other explanatory variables. The T test for statistical significance conducted on the monthly dummy variable representing the month of February resulted in the finding of a .58 probability of obtaining a greater absolute value of T in subsequent tests, meaning that a high probability exists that the coefficient estimate for this variable is not significantly different from zero. In checking for the presence of multicollinearity, the February dummy variable was found to be correlated with the steers on feed variable ($r = -.30$) and the

heifers on feed variable (r = -.33). The dummy variable representing the month of September was also among the group of variables which were not deemed significant at the .10 level or better, having a probability of obtaining a greater absolute value of T of .14. The September dummy was found to be correlated with both the steers on feed (r = .25) and heifers on feed (r = .33) variables. The sum of steers on feed variable was another member of the statistically marginal group, having a .42 probability that the estimated coefficient was not different from zero. However, it was found to have a relatively high correlation with the inventory variable (r = .67) and the sum of heifers on feed variable (r = .82), and, in addition, had a correlation coefficient of -.33 with the slaughter price to feeder price ratio. The variable representing the sum of heifers on feed in the less than 500 and 500-699 lb. class was deemed statistically significant at only the .12 level, but was found to have a relatively high correlation with the sum of steers on feed variable (r = .82) and some correlation with the inventory variable (r = .34). The variable representing the slaughter price to feeder price ratio was found to be statistically significant at only the .23 level, but revealed correlation with both the inventory (r = -.56) and steers on feed (r = =.33) variables. In addition to the high degree of multicollinearity present in the five-month equation, the coefficients were all preceded by the positive sign that economic theory would anticipate. Thus, it was decided that none of the statistically questionable variables should be deleted.

Backcasts over the observation period and forecasts for the months of May, June, July, August, and September of 1973 (time-scale values 57 through 61), based on data collected in December, 1972, and January,

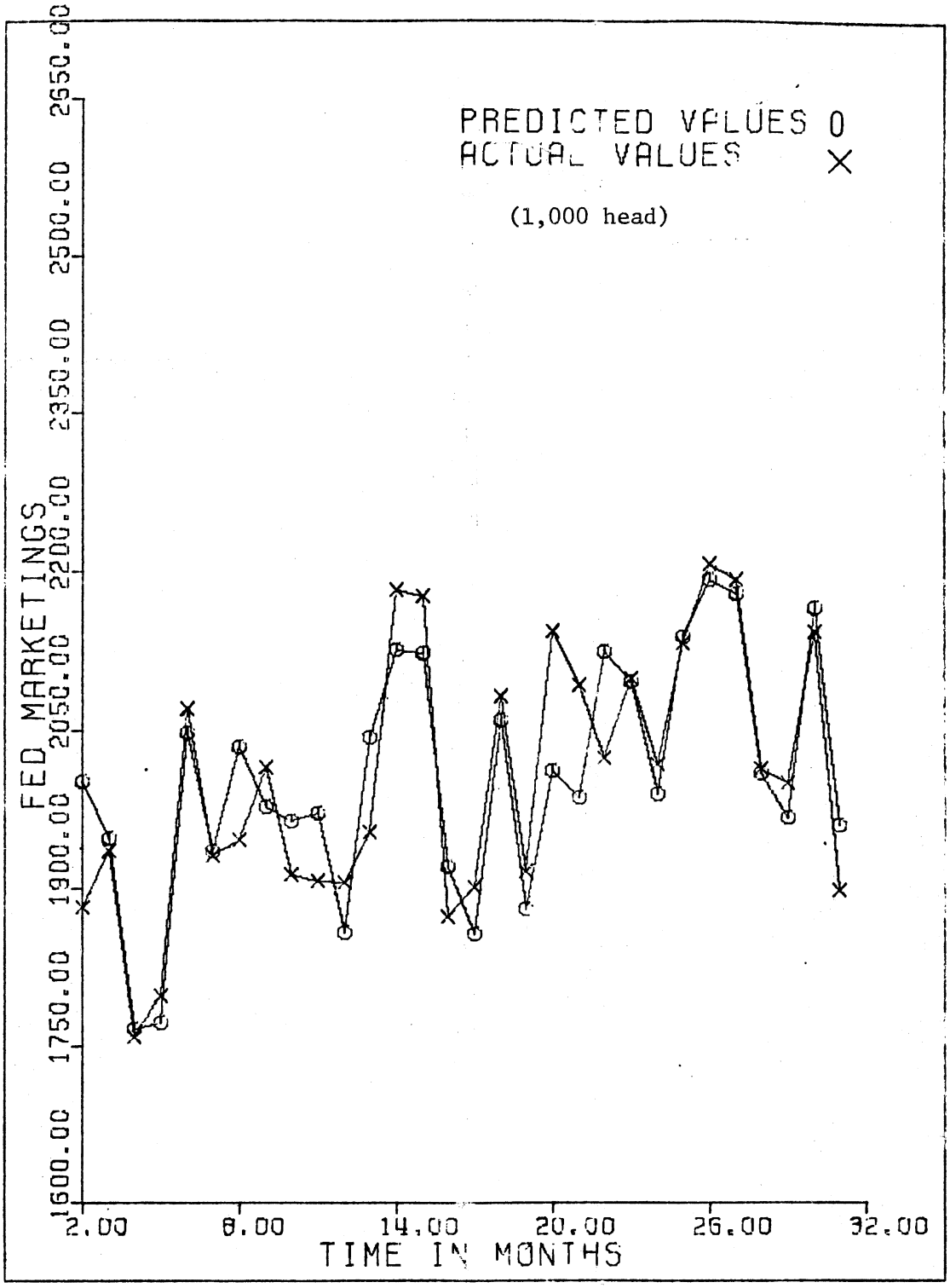

Figure 4. Backcasts, Forecasts and Actual Monthly Fed Marketings, Four-Month Model.

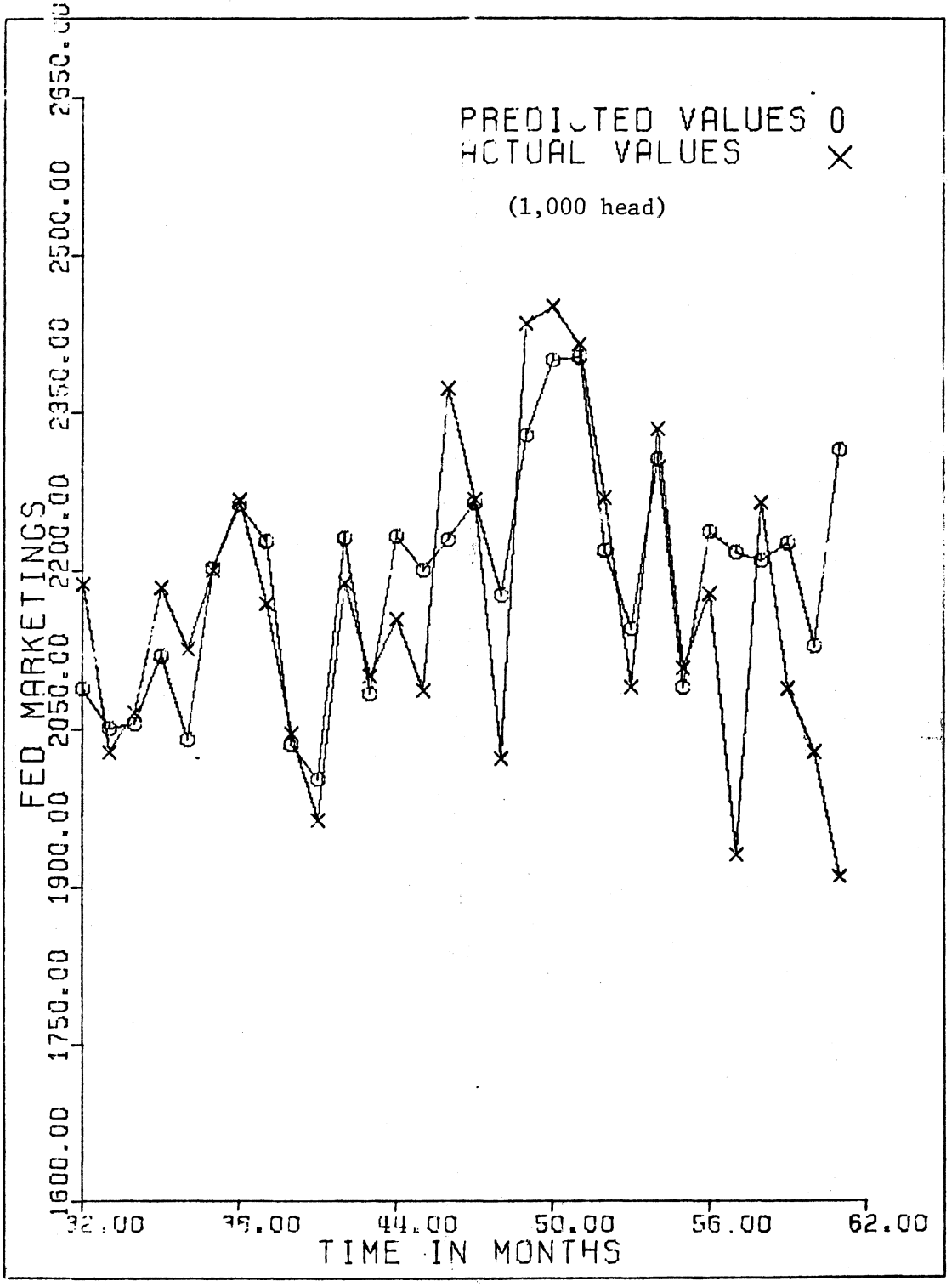

Figure 4. (Continued)

February, March, and April of 1973, are presented in Figure 5. The lines representing predicted and actual fed marketings diverge greatly in June through September of 1973. However, it should be noted that the pattern of actual fed marketings turns sharply upward from August to September, reflecting the increase in fed marketings brought about by the removal of the freeze on beef prices on September 12th.

Six-Month Predictive Equations

The explanatory variables with which the six-month predictive model was constructed include the sum of steers on feed in the under-500 lb., 500-699 lb., and 700-899 lb. categories, the sum of heifers on feed in the under-500 lb., and 500-699 lb. categories, the ratio of the price of Choice 900-1100 lb. steers at Omaha to the price of number 2 yellow corn, the January 1 inventory of beef calves, and monthly dummy variables. Three of the four non-binary variables were found to be of questionable statistical significance. The variable representing the sum of steers on feed had a T-test probability of .84 that the coefficient was not significantly different from zero. However, it was found to be correlated with the inventory variable ($r = .61$), and the heifers-on-feed variable ($r = .80$). Likewise, the coefficient for the sum of heifers on feed in the weight classes previously specified appeared to be of questionable statistical significance but was found to have relatively high correlation with the steers on feed variable ($r = .80$). The beef-corn ratio had a T-test probability of .22 that its coefficient was not significantly different from zero. It was found to have a collinear relationship with the inventory variable ($r = .42$) and the sum of steers on feed ($r = .34$). Due to the substantial degree of multicollinearity

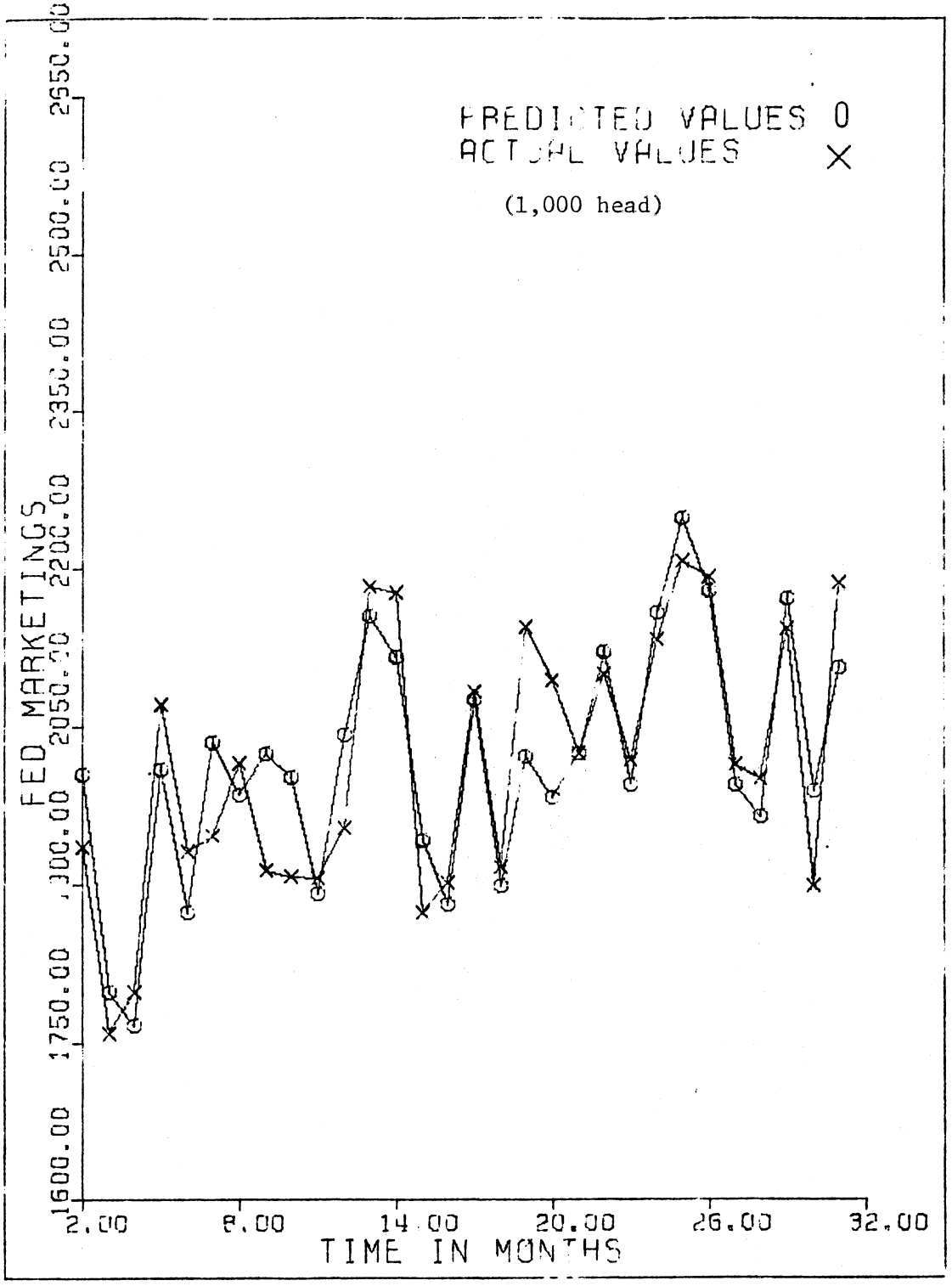

Figure 5. Backcasts, Forecasts and Actual Monthly Fed Marketings, Five-Month Model.

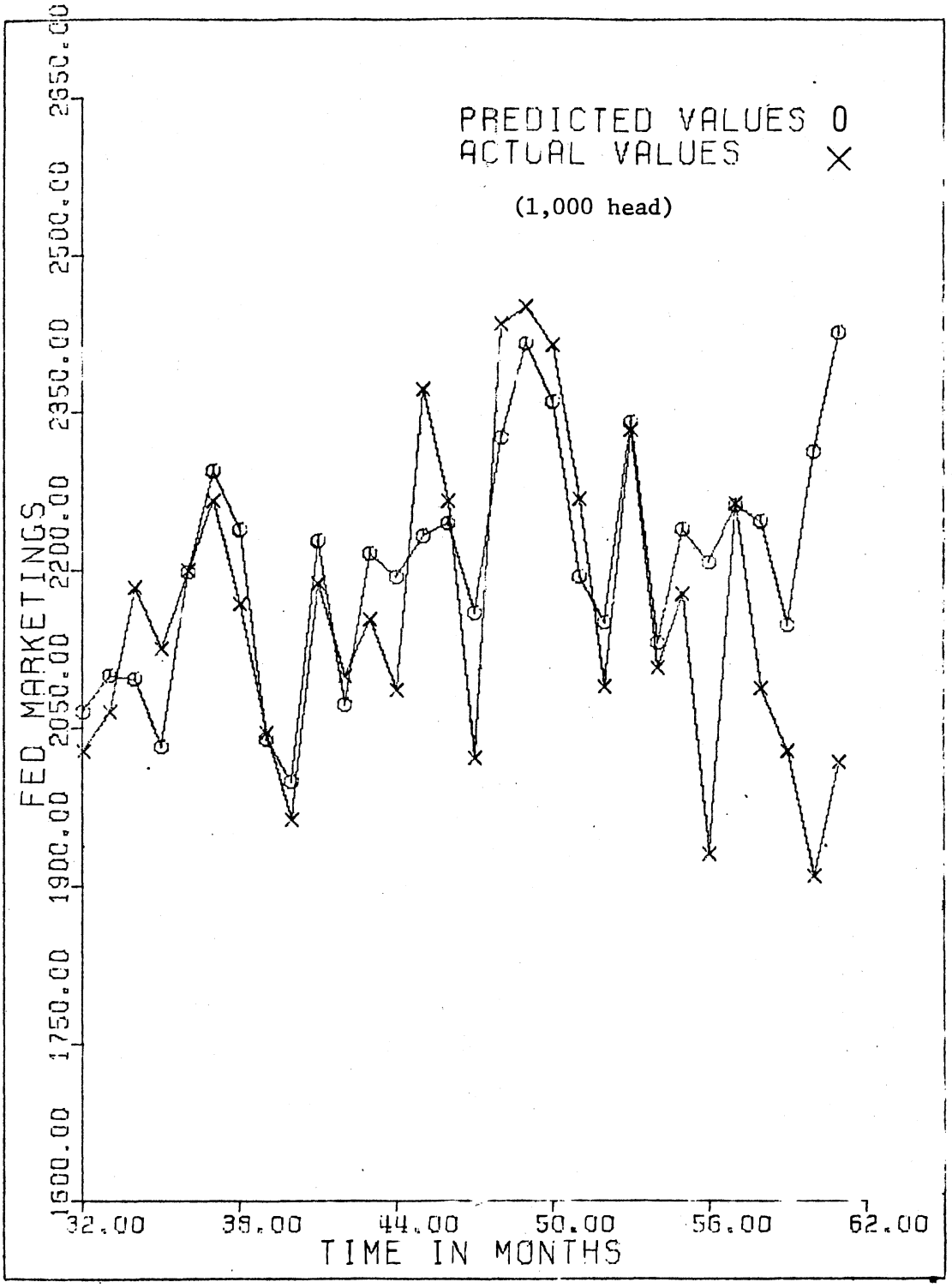

Figure 5. (Continued)

present in the six-month equations coupled with the economic justification for the inclusion of each of the exogenous variables, it was decided that none of the statistically marginal variables should be deleted.

Figure 6 contains plots comparing backcasted values with actual values during the observation period, as well as six-month forecasts projecting the number of fed cattle marketed monthly in May through October (time-scale values 56 through 61) based on information obtained in each of the base months December, 1972 through April 1973. The model again began to accurately predict the direction of change in marketings between August and September, and decreased the magnitude of the forecast error for October to 3.5% of total, 23-state, fed marketings.

Seven-Month Predictive Equations

The model developed to predict fed marketings seven months into the future consisted of the sum of steers on feed in the under-500 lb. and 500-699 lb. weight classes, the number of heifers on feed under 500 lbs., the ratio of the price of Choice 900-1100 lb. steers at Omaha to the price of number 2 yellow corn, the January 1 inventory of beef calves, ratio of the current month's average price of Choice 900-1100 lb. steers at Omaha to the previous month's price, and monthly dummy variables. Three of the five non-binary exogenous variables failed to prove statistically significant at the .05 level. The ratio of the current month to the previous month's average price of Choice steers displayed a significance level of .17, while T-tests for the steers on feed and heifers on feed variables resulted in significance levels of .61 and .24 respectively.

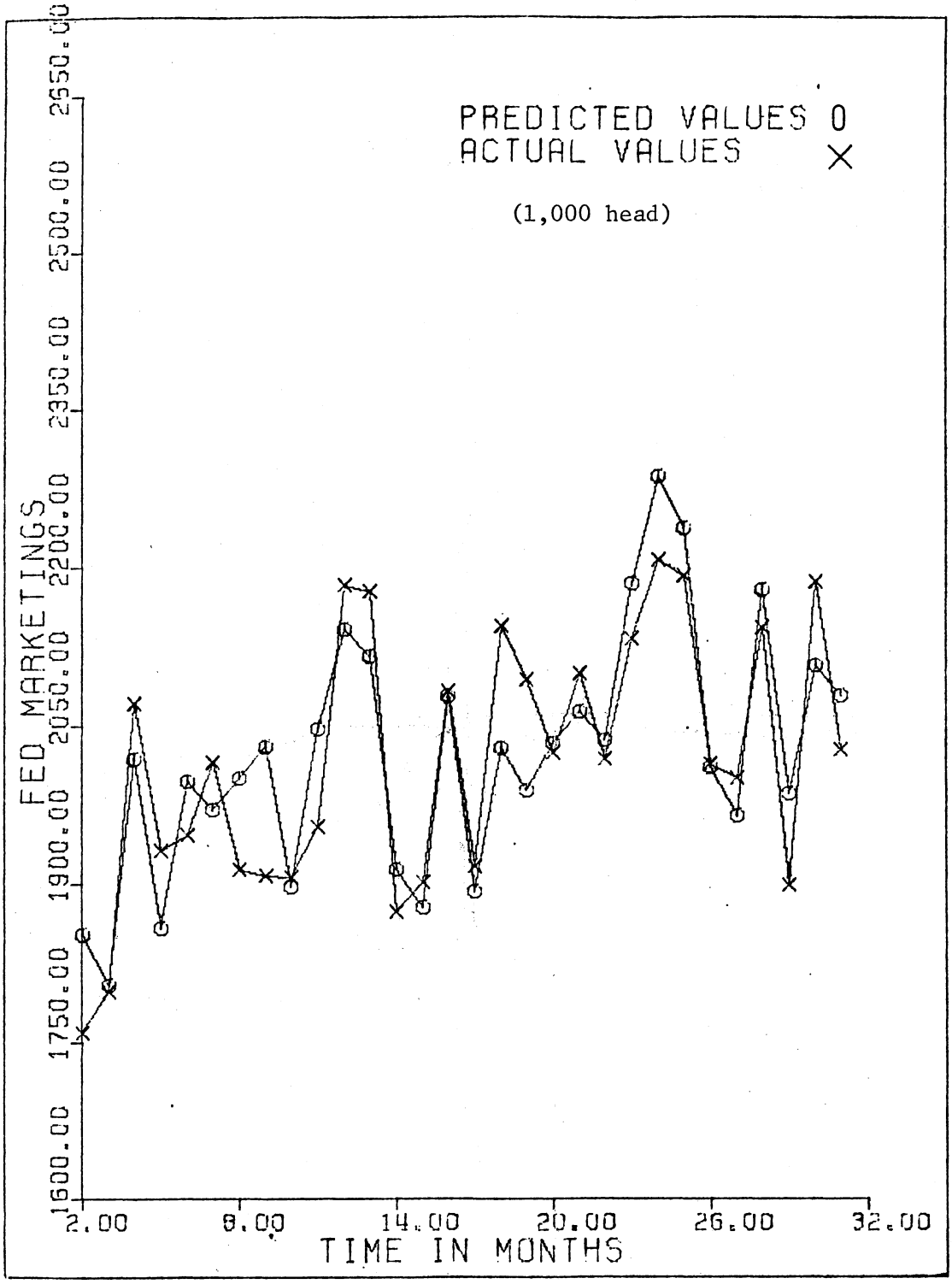

Figure 6. Backcasts, Forecasts and Actual Monthly Fed Marketings, Six-Month Model.

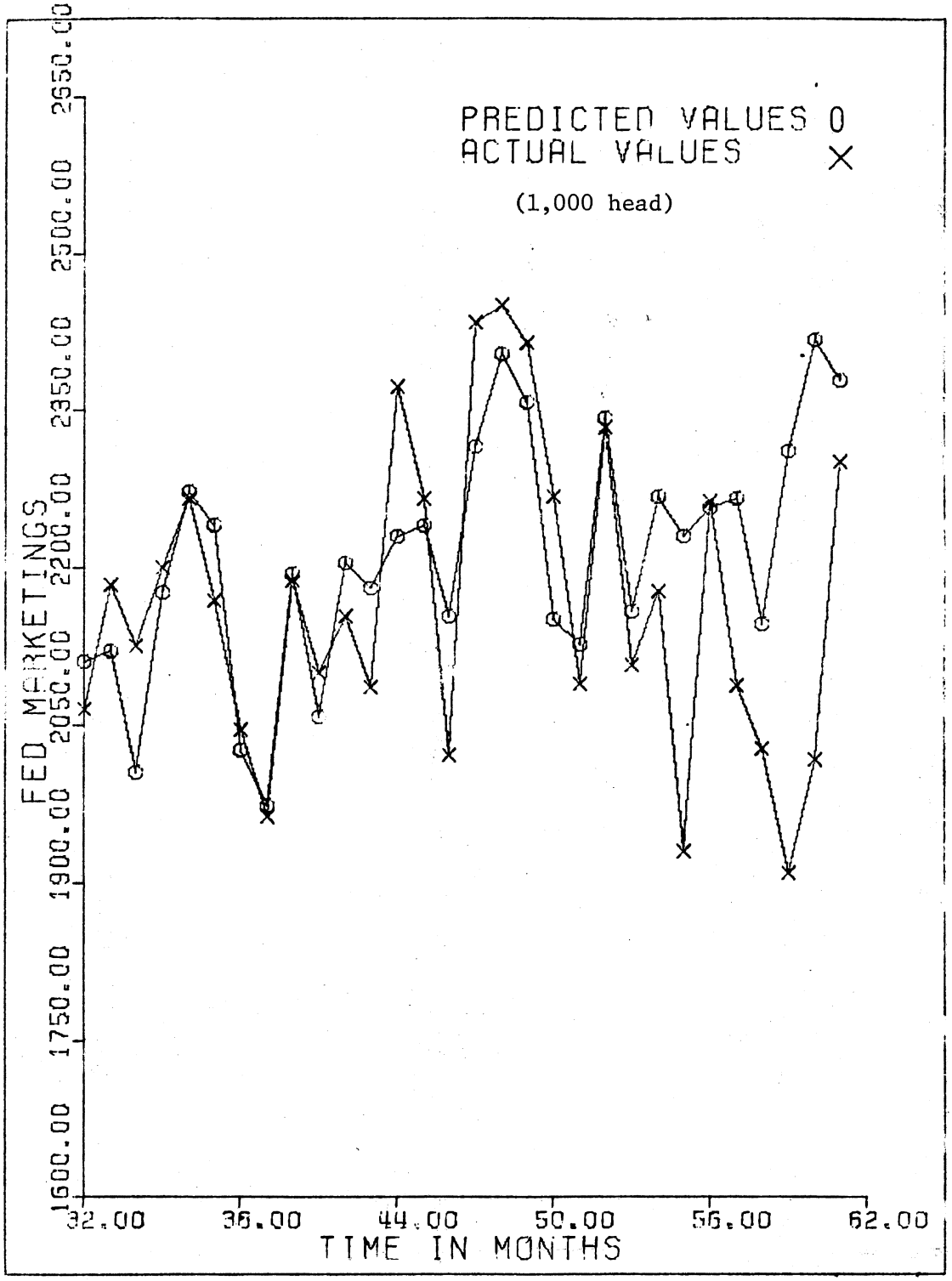

Figure 6. (Continued)

However, the sum of steers on feed and hiefers on feed were found to be correlated (r = .70), and the steers on feed variable displayed a degree of correlation with the inventory variable (r = .42). Therefore, it was decided that the T-tests were not a just criterion for evaluating the usefulness of the exogenous variables because the full impact of each variable was not accurately measured in its estimated parameter. Each of the statistically marginal variables was retained.

Backcasts made for fed marketings during the observation period, and seven month forecasts for each month from May through November 1973 (time-scale values 55 through 61), are compared with actual values in Figure 7. The seven-month predictive model appears to regain accuracy with the forecast for October, missing by only 2.9% of the total. The error diminished further with the November forecast, registering only a 1.8% miss.

Eight-Month Predictive Equations

The eight-month model was constructed using the same exogenous variables as were used in the seven-month model. Of the five non-binary variables only the sum of steers on feed variable failed to show statistical significance at the .05 level or better. It was determined that since the sum of steers on feed was correlated with heifers on feed (r = .70) and inventory (r = .41), the full impact of steers on feed was probably measured in the coefficients of each of the three variables. Therefore, the steers-on-feed variable was retained.

Figure 8 illustrates the model's predictive ability by compared actual values for fed marketings with backcasts made for the observation period, and forecasts for the months of May through December 1973

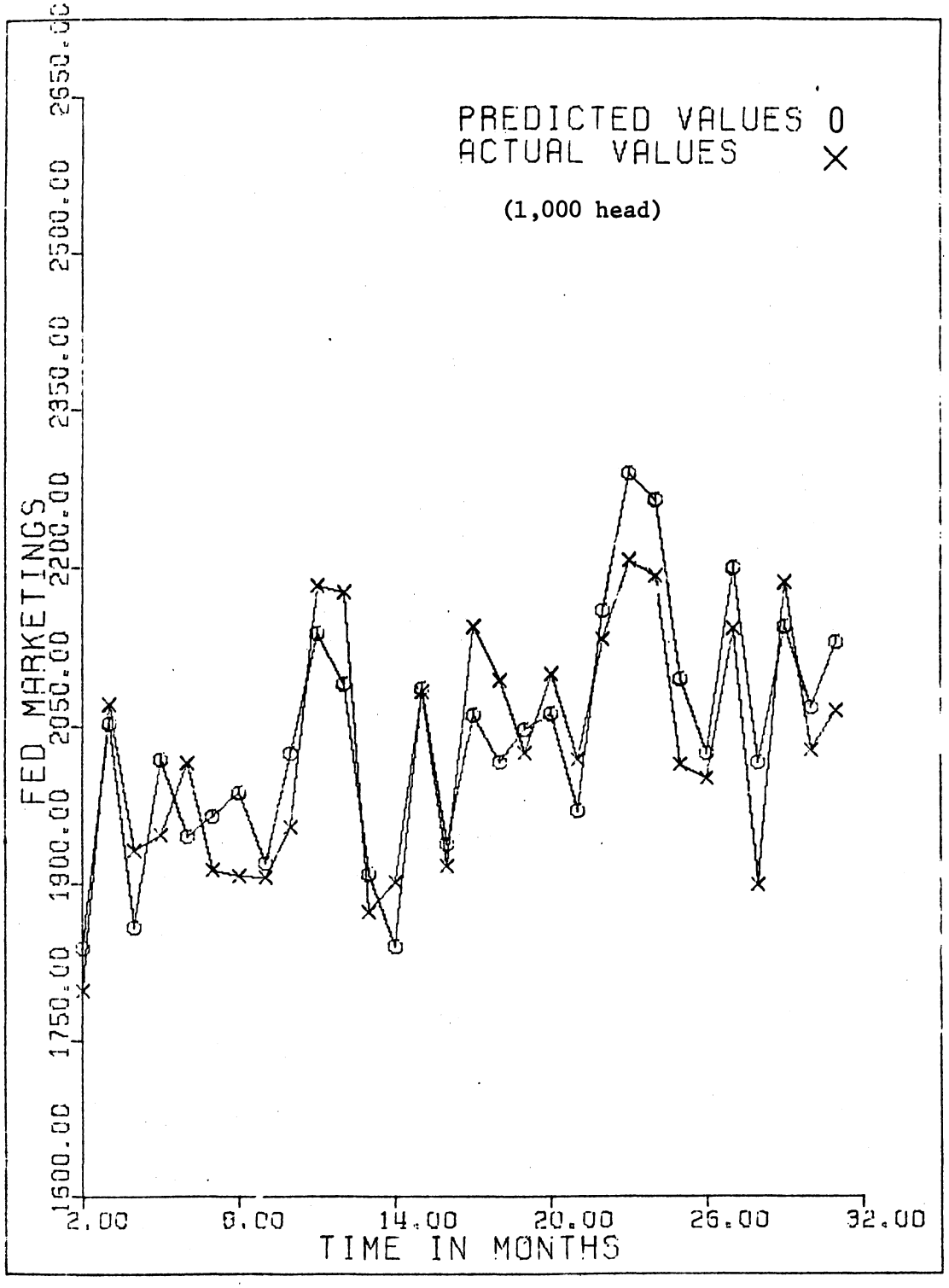

Figure 7. Backcasts, Forecasts and Actual Monthly Fed Marketings, Seven-Month Model.

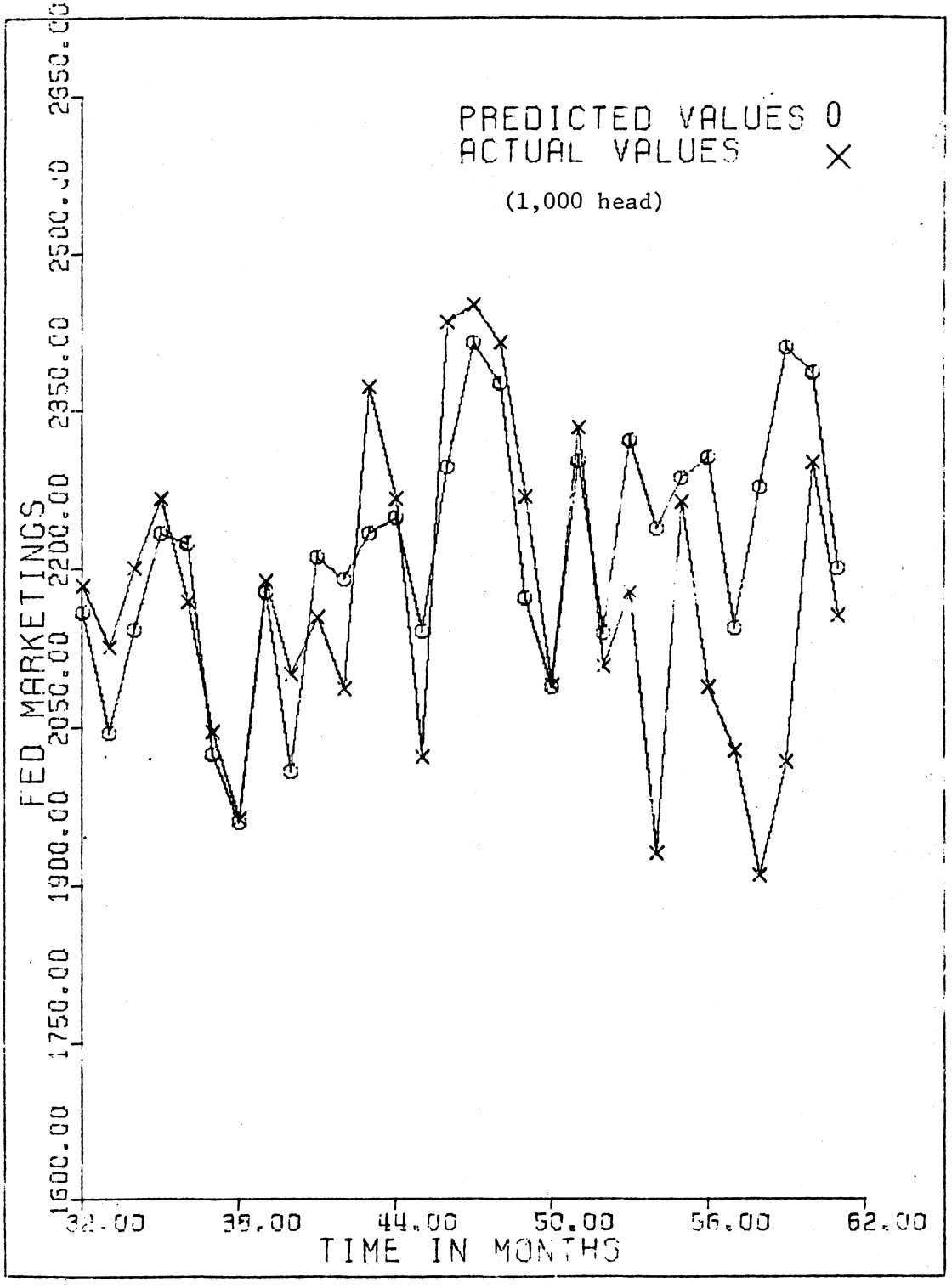

Figure 7. (Continued)

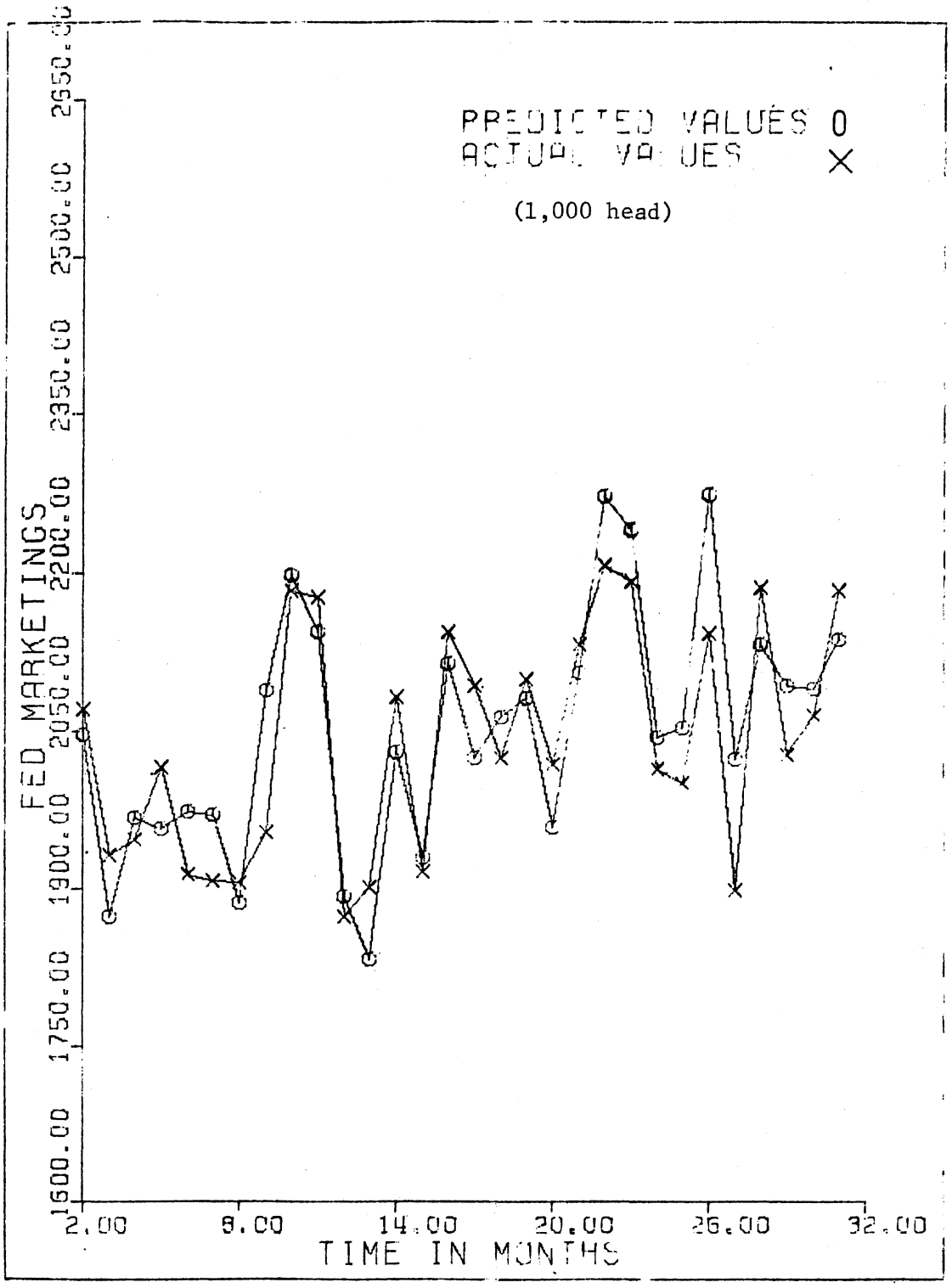

Figure 8. Backcasts, Forecasts and Actual Monthly Fed Marketings, Eight-Month Model.

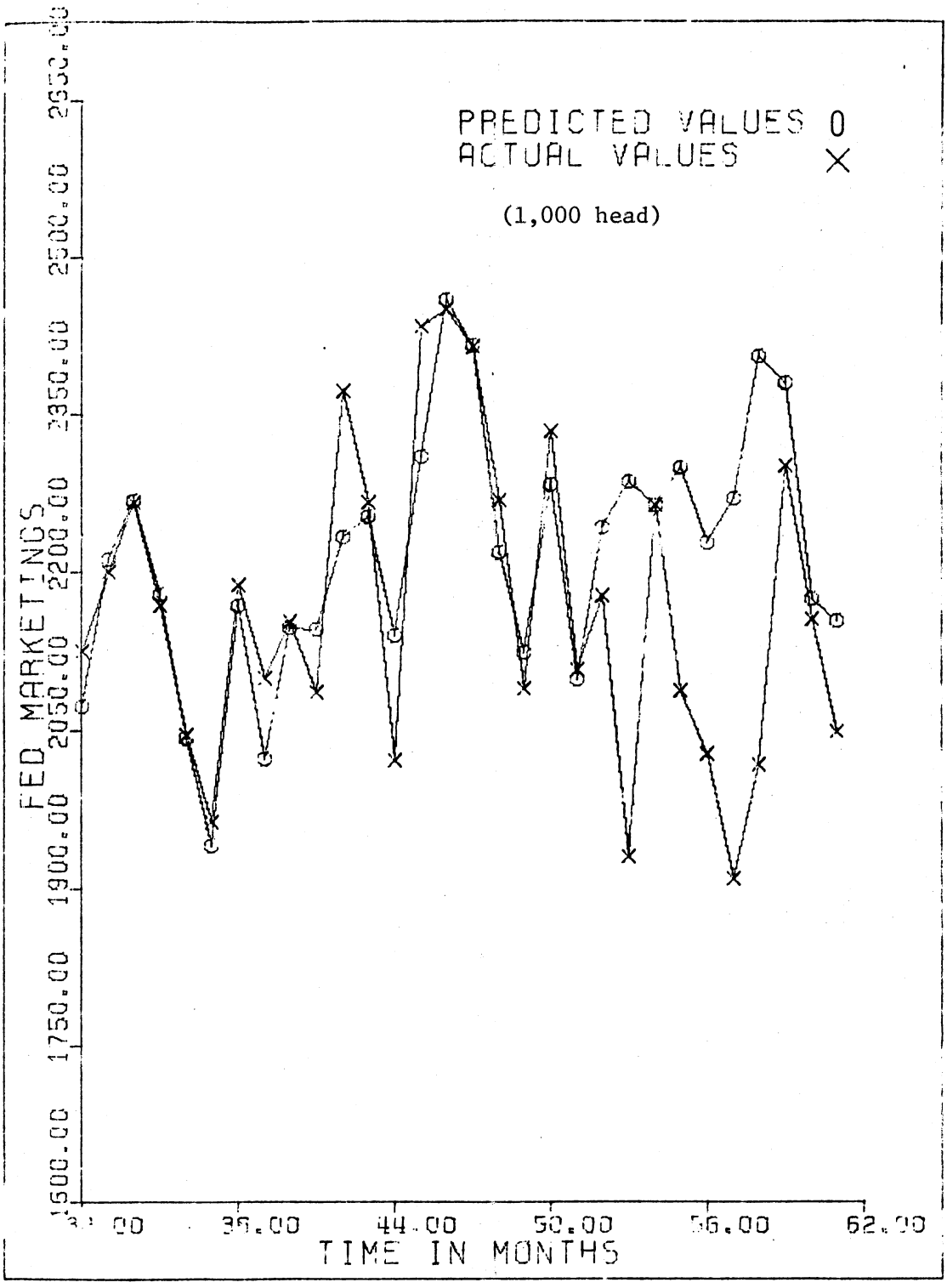

Figure 8. (Continued)

(time-scale values 54 through 61). After registering substantial errors in the forecasts for the months of June through September, 1973, the model appeared to begin regaining its predictive power in October, the first month after lifting of the price freeze on beef. The errors for October, November, and December, were 3.5% of actual fed marketings, 1.1% and 5.3% respectively.

Conclusions and Implications for the Price Model

The analysis conducted to develop accurate fed marketings forecasting models was initiated on the assumption that the number of fed cattle marketed monthly in the 23 major feeding states was the best supply indicator for use in a set of models designed to forecast the monthly price of Choice 900-1100 lb. steers at Omaha. Since 23-state fed marketings are reported by the USDA only on a quarterly basis, an estimation procedure was developed utilizing the monthly seven-state cattle on feed reports to generate a series of monthly estimates of fed marketings in the 23 states for use as the dependent series in the regression equations. Regression analyses of time series data were then undertaken to develop predictive models which could satisfactorily explain monthly variations in fed marketings from one to eight months into the future.

The models were based on data collected in the current time period (month T), and therefore, all explanatory variables are variables to which fed marketings could be expected to display a lagged response. By constructing the equations using lagged explanatory variables, the problem of forecasting values for the independent variables and the

magnification of error which could be expected to accompany the inclusion of these forecasts in the fed marketings predictive models was avoided. Each of the eight models developed displayed good predictive ability, having an R^2 in excess of .80, with a relatively low mean square error and standard deviation. In addition to the regression analyses, graphical presentations were made plotting actual against predicted fed marketings to illustrate predictive ability for each of the models. Fore-errors of substantial magnitude were encountered during the period June, 1973, through September, 1973 in each of the predictive models. However, this period displayed an extremely abnormal pattern of marketings in response to the price freeze on beef from March 27, to September 12. As the months for which the forecasts are made move further away from the period of the price freeze, the accuracy of the model is regained. This reconvergence of actual with predicted fed marketings is best illustrated by Figures 5 through 8, the predicted versus actual fed marketings plots for models T+5 through T+8.

The successful projection of the supply indicator, fed marketings, is a primary prerequisite to accurate forecasting of slaughter steer prices. As the primary supply variable, it is an essential component of the price model and any errors in the forecasting of fed marketings will be immediately reflected in the price forecasts.

FOOTNOTES

[1]U. S. Department of Agriculture, Livestock Slaughter (Washington, D. C., 1968-73).

[2]Ibid.

[3]The seven selected states include California, Arizona, Texas, Kansas, Colorado, Nebraska and Iowa. Kansas was added in 1972 and the data prior to that point were generated by "inflating" the six-state report then published to include Kansas.

[4]At rates of gain of 2.0 to 3.0 lbs. per day a 925 lb. heifer is at approximately the same point on her growth curve as in 1125 lb. steer. Donald G. Wagner, "The Effect of Feedlot In-Weight on the Costs and Efficiencies of Gain," Proceedings, Oklahoma Cattle Feeders Seminar, February, 1971, pp. 6-F.

[5]John T. Larsen, Seasonality of the Cattle Market, ERS-468 (Washington, D. C., January, 1971), pp. 27.

CHAPTER III

FORMULATION OF THE PRICE MODEL

The objective of the price model developed is to forecast the monthly price of fed steers one through eight months into the future. In order to construct such a model, the least square linear regression procedure was used as a framework within which to group the explanatory variables found to be the most relevant in explaining month-to-month variations in fed steer prices. Several variables were tested for relevancy at each of the eight predictive intervals using the step-wise maximum R^2 improvement procedure of the Statistical Analysis System.[1] The maximum R^2 improvement procedure considers the complete set of independent variables and selects from among that set the one-variable model producing the greatest R^2. It then adds variables in the order to their contribution to R^2, thus finding the "best" one-variable model, "best" two variable model, etc. By using this procedure, a large number of independent variables could be tested with relative ease, and the impact of all variables expected to have a lagged effect on price could be explored for each of the time lags. Final selection of variables was based on economic justification, contribution to explanatory power, and statistical significance.

An important step in the development of a price forecasting model is the selection of an appropriate data series to assume the role of dependent variable. The dependent series in a model designed to forecast

monthly price of fed steers must be continuous, readily available, and representative of prices nationally. In addition, it is important to use prices of a particular weight and grade rather than an average price since an average price of all weights and grades could be drastically affected by variation in supply composition. The price of Choice 900-1100 lb. steers at Chicago has been selected as a representative price to use as the dependent series in previous studies.[2] However, in recent years the importance of the Chicago terminal market has declined and the market was closed during 1972. Therefore, the price of Choice 900-1100 lb. steers at Omaha was selected as the series which should reflect, as accurately as possible, national supply and demand for fed cattle.

After carefully selecting the most appropriate dependent variable, attention was turned toward identification of the relevant explanatory variables. The explanatory variables for this model are of two types: variables to which price displays a lagged response, and variables to which price responds in the current time period. It was felt that if variables could be discovered whose impact on price was not realized until after the period in which the value of that variable was observed, the potential error in price forecasts due to possible errors in projection of explanatory variable values could be substantially reduced.

Among the lagged explanatory variables tested in each of the eight models were wholesale beef price, retail beef price, retail pork price, cold storage holdings of frozen and cured pork, percentage of income spent on food by a middle income family, and cold storage holdings of beef. Variables to which price could be expected to respond in the current time period, other than the fed marketings supply variable, include monthly commercial pork production, income, population, and cow

slaughter. Obviously, for purposes of forecasting future price, future values for these explanatory variables are needed. Therefore, projection procedures were developed to obtain values for this subset of independent variables by enlisting the aid of a seasonal index, trend analysis and regression procedures.

Projection of Monthly Commercial Pork Production

In developing a procedure to project pork production, available research was relied upon heavily.[3] Regression analyses of time series data were employed in an effort to project pork production from one through eight months into the future. The dependent series selected for the analysis was the readily available monthly commercial production of pork. Explanatory variables included the various weight classes of hogs and pigs on farms, the number of fully utilized slaughter days within the month for which the forecast is desired, and monthly dummy variables to account for seasonality.

Hogs and Pigs on Farms

The primary determinant of commercial pork production in a particular month is the available supply of slaughter hogs at or near normal market weight during the month. The available supply of market weight hogs is, in turn, primarily determined by the number of market hogs and pigs on farms in a particular weight class during some previous month. To determine the weight class likely to have the greatest impact on pork production in a future month, the length of the growth period remaining between the present time and the month for which the forecast is desired,

the average daily rate of gain, and the normal market weight were combined to produce estimates of the applicable market hogs and pigs weight class for each forecast period. The length of the growth period cannot be restricted to a specific number of days due to the fact that marketings for the forecast month can occur on any day within the month, leaving a possible variation of approximately 30 days. Therefore, a range was assumed for each forecast interval, within which the number of growth days could vary a maximum of 30. Likewise, a range was assumed for rate of gain per day figures due to the wide diversity in rates of gain caused by differences in breed, sex, ration, weather conditions, etc. The rate of gain range used in the calculations stretched from a lower bound of 1.0 lbs. per day to 2.0 lbs. per day. By using a wide range it was felt that virtually all types of operations and levels of efficiency would be included. The determination of normal market weight of slaughter hogs was made by calculating a weighted monthly average of slaughter hogs marketed in the last year of the observation period. Calculations made to arrive at the appropriate weight categories for each of the forecast intervals, using the previously specified growth period ranges, rate of gain range, and market weight, are presented in Table VII.

In attempting to estimate monthly production figures another problem is encountered. USDA reports of the number of market hogs and pigs on farms in the various weight classes are issued on a quarterly basis only. Since monthly information is not available, the quarterly figures were used as inputs in each observation period and the task of determining the pattern of marketings in the months within the period covered by the quarterly reports was assigned to the regression procedure. The

TABLE VII

ESTIMATION PROCEDURE FOR DETERMINING APPLICABLE MARKET HOGS AND PIGS WEIGHT CATEGORY FOR EACH OF THE PREDICTION INTERVALS T-1 THROUGH T-8

Prediction Interval	No. of Days	Rate of Gain Range	Total Pounds of Gain for the Period	Normal Market Weight	Estimate of Beginning of Period Weight Range	Applicable Market Hogs & Pigs Weight Category
T + 1	60 30	2.0 -1.0	30 - 120	240	120 - 210	120 - 179
T + 2	90 60	2.0 -1.0	60 - 180	240	60 - 180	60 - 119 120 - 179
T + 3	120 90	2.0 -1.0	90 - 240	240	0 - 150	<60 60 - 119 120 - 179
T + 4	150 120	2.0 -1.0	120 - 300	240	0 - 120	<60 60 - 119
T + 5	180 150	2.0 -1.0	150 - 360	240	0 - 90	<60 60 - 119
T + 6	210 180	2.0 -1.0	210 - 480	240	0 - 60	<60
T + 7	240 210	2.0 -1.0	210 - 480	240	0 - 30	<60
T + 8	270 240	2.0 -1.0	240 - 540	240	0 - 0	<60

intra-quarter marketing pattern should be detected by the procedure and revealed in the coefficient estimates for the interim months.

Other Explanatory Variables

Exogenous variables included in the analyses, other than the hogs and pigs on farms variables, were a variable representing the number of fully utilized slaughter days per month and monthly dummy variables included to account for the otherwise unspecified influence of seasonal factors.

The fully utilized slaughter day variable was included to account for monthly variations in number of days, weekends, and holidays. The supply of pork within a month was felt to be responsive to the slaughter capacity of packers operating on a normal working schedule subject to the influence of guaranteed work weeks and premiums in hourly wage rates for overtime and holiday work. The number of fully utilized slaughter days within a particular month was calculated by weighting normal weekdays as 1, Saturdays as 1/3, weekday holidas as 1/2, Saturday holidays as 0, and Sundays as 0.[4]

Monthly dummy variables were included to account for seasonally recurring changes in marketing and production patterns caused by such things as temperature, precipitation, etc. The dummy variable representing the month of January was omitted to avoid the statistical problem of singularity in the estimation process. Therefore, the otherwise unaccounted for seasonal effect on production in January will be registered in the measurement of the intercept term.

Results of the Regressions

The regressions run in the attempt to explain monthly variations in commercial pork production displayed exceptionally good fits as far out as six months into the future. The seven and eight month models resulted in slightly poorer fits, perhaps due to the fact that even the lightest weight class reported in the Hogs and Pigs on Farms reports, hogs and pigs less than 60 lbs., gaining at only one lb. per day would normally have reached market weight prior to the seventh and eighth months after the report was issued. Table VIII presents the variable notation and definition for the variables employed in the pork production regressions. In Table IX the results of the regressions are presented.

Projection of Monthly Per Capita Income

The models developed in this study are designed to forecast price at the feeder-packer level of the marketing chain. Determinants of packer demand must be identified and quantified to accomplish this goal. However, since the demand for live steers at the packer-feeder level is derived from retail demand, the principal determinants of retail demand should have a significant impact on the demand for live steers. Probably the most significant components of demand at the retail level are incomes of consumers and population size. Both of these demand shifters are usually measured in the per capita disposable income figures reported on a quarterly basis. However, for the purpose of this analysis monthly figures are required. Therefore, a per capita income figure was calculated by dividing the U. S. total personal income figures reported monthly in the Survey of Current Business by the U. S. population at mid-month reported in the same publication.[5]

TABLE VIII

NOTATION OF VARIABLES IN THE COMMERCIAL PORK PRODUCTION REGRESSIONS

PKPROD = Monthly, commercial pork production, 48 states.

D2-D12 = Monthly dummy variables included in the equation to allow the level of the regression line to shift from month to month due to otherwise unspecified seasonal factors. D2 represents the month of February, D3 March, D4 April, etc. The month of January was denied representation by a dummy variable in order to avoid the statistical problem of singularity in the estimation procedure. Thus, the seasonal effect of January will be in the measurement of the intercept term.

HP1 = Number of market hogs and pigs on farms, reported quarterly, in the major producing states, in the <60 lb. weight class.

HP2 = Number of market hogs and pigs on farms, reported quarterly, in the major producing states, in the 60 - 119 lb. weight class.

HP3 = Number of market hogs and pigs on farms, reported quarterly, in the major producing states, in the 120 - 179 lb. weight class.

HP4 = Number of market hogs and pigs on farms, reported quarterly, in the major producing states, in the 180 - 219 lb. weight class.

HP5 = Number of market hogs and pigs on farms, reported quarterly, in the major producing states, in the $\geq$ 220 lb. weight class.

WKDAYS = Number of fully utilized slaughter days in the month for which the forecast is desired.

TABLE IX

RESULTS OF THE REGRESSIONS TO PROJECT COMMERCIAL PORK PRODUCTION[a]

Dependent Variable	Explanatory Variables					
	Intercept	Monthly Dummy Variables				
		D2	D3	D4	D5	D6
PKPROD T + 1	-1118.868 (229.283)	- 33.716 (32.842)	10.569 (30.279)	6.023 (31.533)	- 47.524 (31.619)	-108.979 (31.734)
PKPROD T + 2	-1266.763 (276.055)	63.684 (38.692)	94.373 (36.031)	106.958 (35.432)	34.677 (37.610)	- 27.111 (35.827)
PKPROD T + 3	-1597.786 (249.137)	- 32.433 (30.854)	115.289 (30.554)	122.899 (29.846)	73.159 (31.343)	50.156 (35.439)
PKPROD T + 4	-1371.599 (271.431)	- 30.168 (34.970)	9.026 (31.989)	84.439 (32.427)	40.194 (34.466)	- 16.067 (34.419)
PKPROD T + 5	-1826.542 (291.965)	322.103 (60.722)	355.151 (59.994)	366.735 (59.319)	390.238 (66.922)	333.270 (66.981)
PKPROD T + 6	-1832.439 (282.434)	- 31.376 (33.065)	387.483 (58.352)	395.726 (57.599)	340.374 (57.786)	365.308 (65.050)
PKPROD T + 7	-1553.111 (327.703)	- 23.086 (40.307)	5.948 (36.718)	272.380 (52.919)	220.334 (54.608)	162.905 (54.578)
PKPROD T + 8	- 894.367 (339.183)	-386.223 (91.676)	-346.840 (87.031)	-337.942 (87.709)	-179.570 (54.249)	-235.810 (53.954)

TABLE IX (Continued)

Dependent Variable	Explanatory Variables					
	D7	D8	D9	D10	D11	D12
PKPROD T + 1	57.964 (41.046)	125.008 (41.008)	254.217 (40.823)	- 2.533 (37.181)	44.628 (38.052)	- 5.144 (36.962)
PKPROD T + 2	-116.833 (35.962)	201.712 (54.490)	336.068 (54.555)	367.971 (54.848)	94.463 (34.253)	37.058 (33.136)
PKPROD T + 3	- 38.707 (34.550)	28.365 (34.529)	16.491 (75.794)	54.630 (76.482)	103.047 (75.864)	38.845 (27.758)
PKPROD T + 4	.261 (40.081)	62.017 (39.161)	193.153 (39.212)	-285.508 (61.105)	-234.873 (61.914)	-298.503 (60.968)
PKPROD T + 5	245.259 (67.071)	414.502 (73.479)	541.977 (73.766)	575.131 (74.249)	93.498 (31.719)	37.417 (30.600)
PKPROD T + 6	277.888 (65.160)	345.888 (65.160)	563.064 (71.097)	606.702 (72.187)	656.154 (71.618)	38.614 (29.638)
PKPROD T + 7	139.385 (62.176)	207.385 (62.176)	329.689 (62.215)	463.313 (75.167)	522.985 (75.433)	464.650 (75.012)
PKPROD T + 8	-323.346 (53.888)	-201.444 (48.212)	-81.882 (48.782)	-44.778 (48.393)	94.592 (46.015)	38.379 (41.920)

TABLE IX (Continued)

Dependent Variable	Market Hogs and Pigs Weight Classes					R^2	Durbin-Watson
	HP1	HP2	HP3	HP4	WKDAYS		
PKPROD T + 1			.044 (.027)	.104 (.038)	60.107 (9.219)	.87	.979
PKPROD T + 2		-.004 (.003)	.099 (.015)		66.293 (10.381)	.85	1.006
PKPROD T + 3	.043 (.009)	.004 (.003)	.074 (.014)		60.944 (9.009)	.89	1.310
PKPROD T + 4	.069) (.009)	.004 (.003)			62.423 (10.240)	.85	1.030
PKPROD T + 5	.072 (.009)	.005 (.003)			65.220 (9.991)	.86	1.420
PKPROD T + 6	.075 (.009)	.007 (.003)			61.634 (9.805)	.87	1.260
PKPROD T + 7	.058 (.009)				67.046 (12.051)	.81	.761
PKPROD T + 8	.049 (.010)				62.337 (14.071)	.75	.568

[a]The figures in parentheses are the standard errors of the regression coefficients.

In order to use the calculated per capita income figure to forecast price, a projection procedure had to be developed to accurately forecast the value of that variable. Plots of the data series for both total personal income and population over the period April, 1968, through April, 1973, revealed a consistent pattern of gradual increase. Thus, it was felt that simple trend analyses would provide an adequate fit and basis for projection. The subsequent analyses of both total personal income and population revealed R^2's of .987 and .997 respectively. Further results of the analyses are presented in Tables X and XI.

Projection of Monthly Cow Slaughter

The number of cows slaughtered under Federal Inspection in the 48 states, as reported monthly by the Statistical Reporting Service, USDA, was chosen as an explanatory variable because it was felt to be representative of the lower grades of beef which compete with the Choice grade for the consumer's meat dollar. It was expected that as cow slaughter increased, the subsequent reduction in price of the lower quality beef would lead to a decrease in demand for Choice beef, eventually resulting in a drop in the price of Choice steers.

Since the seasonal component of cow slaughter has been reported in previous studies to contribute as much as 66% toward explaining month-to-month variation in cow slaughter, it was felt that the most efficient use of time and resources could be achieved by calculating a seasonal index to project cow slaughter in future time periods.[6] A twelve-month centered moving average was used to compute the index which is presented in Table XII.

TABLE X

ESTIMATED EQUATION TO PROJECT
TOTAL PERSONAL INCOME

Dependent Variable	Intercept	Time (Months)	R^2
Total Personal Income	662.835	5.298	.987

TABLE XI

ESTIMATED EQUATION TO PROJECT
U. S. POPULATION

Dependent Variable	Intercept	Time (Months)	R^2
Population	200.569	.159	.997

TABLE XII

SEASONAL INDEX OF COW SLAUGHTER

Month	Index
January	102.432
February	88.810
March	94.720
April	92.776
May	93.529
June	100.574
July	102.202
August	101.951
September	101.616
October	114.649
November	104.917
December	101.824

Exogenous Variables Toward Which Slaughter Price Displays a Lagged Response

The price of wholesale dressed beef (600-700 lb.) at Chicago was selected as a lagged explanatory variable to be tested for impact at each of the eight monthly predictive intervals. Since the demand for beef is a derived demand the effect of the price paid for beef at the wholesale level could be expected to filter down to the live market and be reflected in the price of live steers within a relatively short time. The pattern of price movement of live steers should closely approximate movements in wholesale price after sufficient time has elapsed for the direction of change in price at the wholesale level to be translated into estimates of probable increase or decrease in demand for live steers. Therefore, assuming the appropriate time lag can be isolated, the price of beef at the wholesale level could be expected to have a substantial positive impact on live steer price.

The average monthly retail price of Choice beef was selected as an explanatory variable for much the same reason as wholesale beef price. However, it was anticipated that the time lag necessary for retail price to filter down through the marketing chain and be reflected in the price of live steers would be greater than the lag for wholesale price. Thus, the retail price series could contribute significantly to the explanatory power of the models in later periods in which wholesale price in the current month had little influence.

Another price series deemed useful for incorporating as a lagged exogenous variable was the average monthly retail price of pork. Previous studies indicate that in recent years the price of most substitutes

has had only a negligible impact on the demand for beef, the notable exception being the price of pork. Pork price could theoretically be expected to have a positive impact on the price of Choice steers. That is, as pork price increases (decreases) relative to the price of beef, consumers could be expected to shift a portion of their meat purchases from (to) pork to (from) beef causing an upward (downward) shift in the demand for beef and upward (downward) pressure on price.

Monthly cold storage holdings of frozen and cured pork were also tested for predictive ability at each of the eight monthly forecast intervals. Pork storage, as a component of total available supply of pork, could be expected to have a negative effect on the price of beef at some future point in time. As storage holdings of pork increase (decrease), the potential for decreases (increases) in the price of pork in the future grows, resulting in an ever-increasing possibility of future downward (upward) shifts in the demand for beef.

The percentage of income spent on food by a hypothetical family of four under a moderate cost plan representative of a family from the middle one-third of the U. S. income distribution was also selected for testing as a lagged explanatory variable which could have a substantial impact on slaughter steer price. It was anticipated that as the percentage of income spent on food by a representative segment of the American population increased, consumers would shy away from the higher priced beef items in an attempt to cut their total food expenditures. This slackening of demand would result in lower prices for Choice beef at retail which, in turn, would be translated into lower prices for Choice slaughter steers in the live market after a certain amount of time had transpired. The opposite reaction in the live cattle market could

be expected as the percentage of income spent on food decreases.

Another component of the available supply of beef heretofore excluded from the analysis is the end-of-month cold storage holdings of frozen and cured beef. Although cold storage holdings have not represented a substantial share of total available beef supply in recent years, the easily obtainable current month values do have the potential to contribute to the explanatory power of forecasting equations for future months. Therefore, the beef storage series was tested in each of the eight models.

Interpretation of and Reasons for the Use of Intercept Dummies

In recent years, the seasonal component of Choice steer price fluctuations is reported to have accounted for approximately 37% of the month-to-month variation in price.[7] Although this is not extremely high relative to the contribution of seasonality in explaining the variations in such things as fed marketings, feeder cattle placements, cattle slaughter or average market weight, it is of enough significance to warrant its inclusion in the development of any model designed to forecast the price of fed steers. For this reason, monthly dummy variables were included in the analysis to account for the seasonal effects of weather, production cycles, consumer buying patterns related to such things as holidays, temperature, etc.

FOOTNOTES

[1]Jolayne Service, A User's Guide to the Statistical Analysis System (Raleigh, August, 1972), p. 128.

[2]Marvin Hayenga and Duane Hacklander, Short-Run Livestock Price Prediction Models, Research Bulletin 25 (East Lansing, 1970), p. 5 and D. D. Rohdy, G. H. Hoffman, A. G. Madsen, Short-Run Price Forecasting Model for Fed Cattle, Technical Bulletin 108 (Fort Collins, December, 1969), p. 10.

[3]Hayenga and Hacklander, pp. 10-15.

[4]The computation procedure for determining the values of the fully utilized slaughter day variable was taken from page 18 of the Hayenga and Hacklander study cited above.

[5]U. S. Department of Commerce, Survey of Current Business (Washington, D. C., April, 1968-April, 1973).

[6]John T. Larson, Seasonality of the Cattle Market, ERS-468 (Washington, D. C., January, 1971), p. 27.

[7]Ibid.

CHAPTER IV

RESULTS OF THE PRICE MODEL

Incorporating the previously specified variables into an analysis of the price of Choice 900-1100 lb. steers at Omaha produced models with acceptable statistical properties for each of the eight predictive intervals. R^2's ranged from .96 (standard deviation = 1.07 with mean price = 31.90) in the one-month predictive model to a low of .93 (standard deviation = 1.37 with mean price = 32.54) in the eight-month model. Table XIII provides a list of variable names and definitions for all the variables contained in the eight models. Table XIV presents the regression coefficient values and accompanying standard errors, as well as R^2, standard error of the forecast, and Durbin-Watson statistic for each of the models.

In some models, the standard error of the regression coefficient for one or two of the sets of eleven monthly dummy variables appears to be relatively high, resulting in marginally acceptable test statistics. The relatively poor test statistics can be partially explained by the fact that factors normally attributed to seasonality, such as production cycles and marketing patterns associated with weather and crop seasons, are accounted for in the coefficient estimates of the fed marketings, pork production, and cow slaughter variables. Thus, the specification of explanatory variables other than the set of monthly dummies partially determines the statistical importance of the dummy variables in each

TABLE XIII

DEFINITION OF VARIABLES IN THE PRICE REGRESSIONS

SLT-PRC	= Average monthly price, in dollars per cwt., of Choice 900-1100 lb. slaughter steers at Omaha.
D2-D12	= Monthly dummy variables included in the equation to allow the level of the regression line to shift from month to month due to otherwise unspecified seasonal factors. D2 represents the month of February; D3, March; D4, April; etc. through D12 which represents December. The month of January was denied representation by a dummy variable in order to avoid the statistical problem of singularity in the estimation procedure. Thus, the seasonal effect of January will be in the measurement of the intercept term.
FEDMKG	= Projected Monthly, 23-state, fed marketings in month t + i.
PERCAP	= Ratio of projected monthly U. S. total personal income, seasonally adjusted, at annual rates to projected monthly U. S. population, in month t + i.
PKPROD	= Projected commercial pork production, 48 states, in month t + i.
RPRKPRC	= Average monthly retail price of pork in month t.
PRKSTR	= Frozen and cured cold storage holdings of pork in 48 states at the end of month t.
WBFPRC	= Average monthly price of wholesale dressed beef (600-700 lb.) at Chicago in month t.
RBFPRC	= Average monthly retail beef price, Choice grade, in month t.
PCT-FOOD	= Percentage of income spent on food by a hypothetical family of four under a moderate cost plan representative of a family from the middle one-third income group.
CWSLGT	= Projected number of cows slaughtered under federal inspection 48 states, in month t + i.
BFSTOR	= Frozen and cured cold storage holdings of beef in 48 states at the end of month t.

TABLE XIV

ESTIMATED REGRESSION EQUATIONS FOR THE PRICE MODELS [a]

Dependent Variable	Explanatory Variables						
	Intercept	D2	D3	D4	D5	D6	D7
SLT-PRC T + 1	- 7.347	- .531 (.837)	.758 (.785)	.271 (.881)	.536 (.803)	- .339 (.777)	-1.460 (.801)
SLT-PRC T + 2	-10.266	- .015 (1.053)	2.041 (1.038)	1.955 (1.205)	1.420 (1.053)	.373 (.982)	-1.654 (1.027)
SLT-PRC T + 3	-11.891	- .001 (1.083)	2.132 (.965)	1.522 (1.164)	1.241 (1.083)	.293 (1.164)	-2.183 (1.504)
SLT-PRC T + 4	62.510	-.078 (1.070)	2.191 (.936)	1.744 (1.059)	.204 (1.244)	-.201 (1.142)	-2.765 (1.286)
SLT-PRC T + 5	-12.489	.460 (1.114)	2.848 (.979)	2.136 (1.086)	1.198 (1.028)	.070 (1.006)	-2.763 (1.162)
SLT-PRC T + 6	-86.894	1.243 (1.222)	4.507 (1.301)	3.761 (1.346)	2.373 (1.175)	.715 (1.074)	-1.126 (1.038)
SLT-PRC T + 7	-19.854	1.781 (1.322)	5.940 (1.800)	6.098 (2.100)	5.257 (1.797)	3.808 (1.479)	.924 (1.429)
SLT-PRC T + 8	- 2.960	- .432 (1.085)	1.543 (.994)	1.175 (1.098)	1.639 (1.007)	1.708 (1.021)	- .242 (1.181)

TABLE XIV (Continued)

Dependent Variable	Explanatory Variables							
	D8	D9	D10	D11	D12	FEDMKG	PERCAP	PKPROD
SLT-PRC T + 1	-1.502 (.791)	-1.028 (.767)	-1.532 (.716)	-1.853 (.794)	- .850 (.861)	- .004 (.002)	6.658 (1.422)	- .006 (.002)
SLT-PRC T + 2	-1.037 (.982)	- .091 (1.035)	-1.291 (1.025)	-2.807 (1.004)	-1.488 (1.115)	- .007 (.002)	13.404 (1.713)	- .011 (.004)
SLT-PRC T + 3	-1.934 (1.503)	- .959 (1.177)	-1.916 (.977)	-2.572 (1.120)	-1.857 (1.195)	- .008 (.003)	12.731 (1.235)	- .010 (.004)
SLT-PRC T + 4	-2.517 (1.371)	-1.867 (1.306)	-2.691 (1.041)	-3.432 (1.091)	-1.886 (1.292)	- .009 (.003)	9.973 (3.029)	- .010 (.004)
SLT-PRC T + 5	-2.141 (1.250)	-2.841 (1.485)	-4.523 (1.563)	-4.947 (1.176)	-2.523 (1.027)	- .008 (.002)	11.266 (1.474)	- .013 (.003)
SLT-PRC T + 6	- .186 (.965)	- .019 (.988)	-3.241 (1.151)	-4.793 (1.158)	-2.480 (1.082)	- .008 (.003)	14.316 (3.251)	- .016 (.004)
SLT-PRC T + 7	2.041 (1.299)	2.278 (1.209)	- .409 (1.029)	-3.711 (.960)	-3.231 (1.123)	- .010 (.003)	10.255 (1.693)	- .012 (.004)
SLT-PRC T + 8	.995 (1.139)	1.002 (1.045)	-1.114 (.988)	-3.499 (1.021)	-2.721 (1.087)	- .011 (.003)	14.104 (.845)	- .004 (.003)

TABLE XIV (Continued)

Dependent Variable	Explanatory Variables							R^2	Durbin-Watson
	RPRKPRC	PRKSTR	WBFPRC	RBFPRC	PCT-FOOD	CWSLGT	BFSTOR		
SLT-PRC T + 1			.411 (.077)	.005 (.006)		.013 (.006)		.96	1.34
SLT-PRC T + 2	-.084 (.056)		.144 (.091)	.012 (.009)		.028 (.007)		.94	1.28
SLT-PRC T + 3		.005 (.006)	.109 (.098)	.009 (.009)		.029 (.008)		.93	1.11
SLT-PRC T + 4		.009 (.005)		.010 (.008)	-2.717 (2.052)	.029 (.007)		.94	.96
SLT-PRC T + 5	.025 (.088)	.020 (.009)				.036 (.008)		.94	1.08
SLT-PRC T + 6	.197 (.091)	.025 (.009)			2.652 (2.170)	.040 (.008)		.94	1.37
SLT-PRC T + 7	.249 (.118)	.029 (.011)				.040 (.010)	-.007 (.005)	.94	1.24
SLT-PRC T + 8						.019 (.008)	-.013 (.007)	.93	1.21

[a]The figures in parentheses are the standard errors of the estimated coefficients.

model. However, the set of dummy intercept shifters was found to contribute substantially to explanatory power in each of the eight models and were retained for this and economic reasons.

The Prediction Equations

One-Month Predictive Equations

The model designed to forecast steer price one month into the future consisted of the set of monthly dummy variables; the projected exogenous variables representing fed marketings, per capita income, pork production, and cow slaughter; and the lagged exogenous variables representing wholesale beef price and retail beef price. All non-binary variables except the fed marketings and retail beef price variables were found to be significant at the .05 level. Fed marketings was correlated with per capita income ($r = .66$), wholesale beef price ($r = .46$) and retail beef price ($r = -.54$). Despite this collinear relation, the fed marketings variable still displayed a significance level of better than .09. A degree of correlation was also discovered between retail beef price and each of the following variables: fed marketings ($r = -.54$), per capita income ($r = -.64$) and wholesale beef price ($r = -.67$). Due to the correlation between the fed marketings and retail beef price variables and other exogenous variables in the one month model, it was suspected that the total impacts of fed marketings and retail beef price were not registered in their estimated parameters. Therefore, deletion of these variables from the one-month predictive model did not seem justified.

The results of the regression analysis revealed that at a slaughter price mean of $31.90, the standard deviation of price about the mean

was $1.07. Residuals ranged from a high of -$1.99 in May, 1970 to a low of $.00 in June of the same year. However, predictive accuracy of a model whose sole purpose is forecasting the dependent variable is best judged, not be test statistics or values computed by using actual values for variables which must later be projected, but by comparing the actual values of the dependent series with those values generated by the forecasting procedure itself. Such an illustration of the predictive ability of the one-month model is presented in Figure 9. Backcasts for the observation period June, 1968 through April, 1973 are presented. The backcasted values were computed using projected values for the exogenous variables rather than the actual values used in the regression procedure. By using projected values for the exogenous variables, the backcasts should provide a more accurate illustration of the model's predictive ability. Deviations or "misses" ranged from $0 in several months to $2.63 in May, 1970 (time-scale value 25).

A forecast was made using April of 1973 as the base period or "current" month and projecting the average monthly price of Choice 900-1100 lb. slaughter steers in May, one month outside of the observation period. This forecast is presented as the last point plotted on Figure 9 (time-scale value 61).

Two-Month Predictive Equations

The two-month forecasting model was composed of the set of monthly dummy variables; the projected exogenous variables fed marketings, per capita income, pork production, and cow slaughter; and the lagged exogenous variables wholesale beef price, retail beef price, and retail pork price. Three of the non-binary variables failed to display

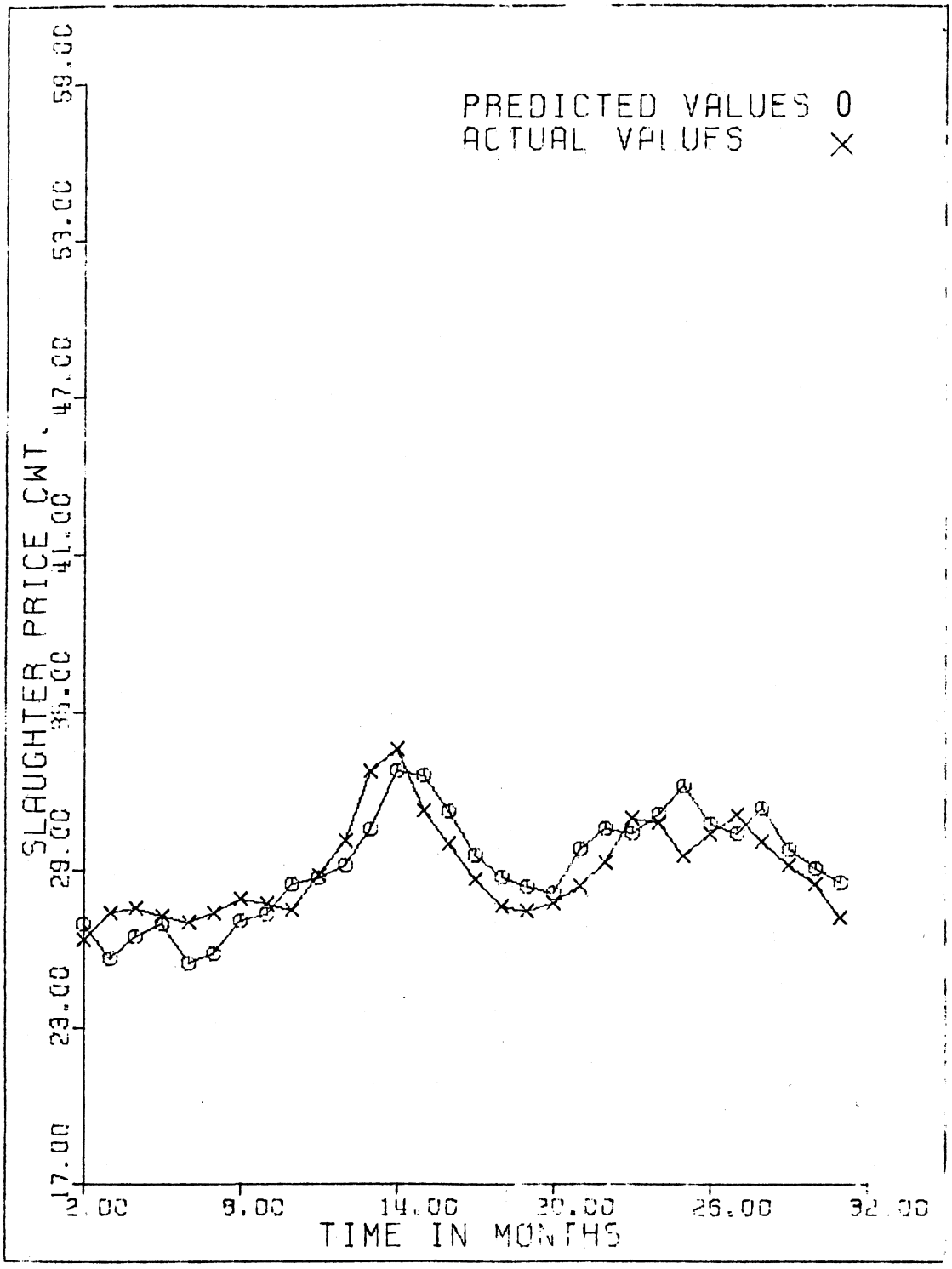

Figure 9. Backcasts and Actual Monthly Choice Steer Prices, One-Month Model.

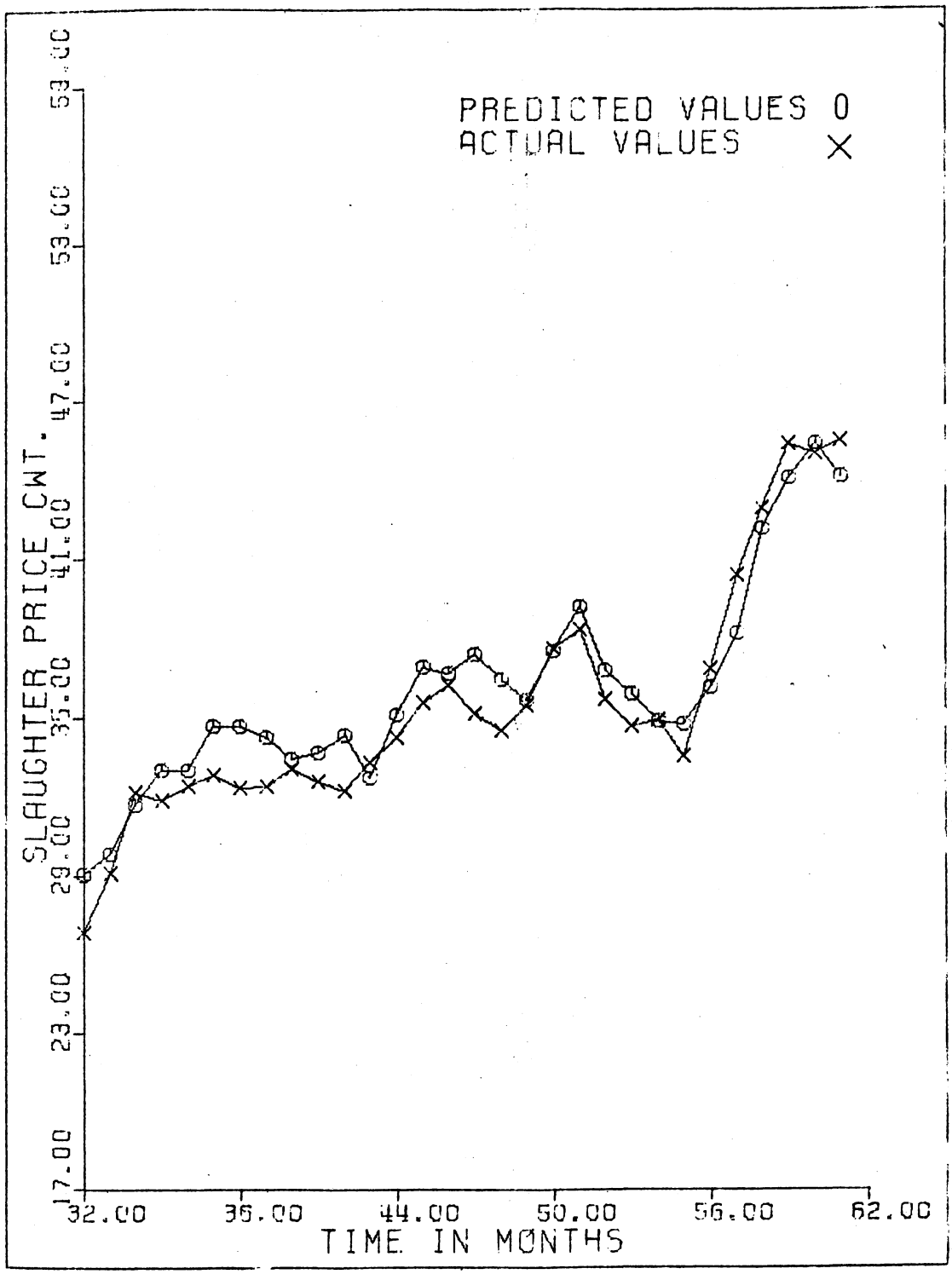

Figure 9. (Continued)

significance at the .05 level or better: wholesale beef price (.12), retail beef price (.18), and retail pork price (.14). Wholesale beef price was found to be correlated with fed marketings (r = .54), per capita income (r = .84), retail pork price (r = .59), and retail beef price (r = -.72). Correlation was also measured between the retail beef price variable and fed marketings (r = -.59), per capita income (r = -.66), and wholesale beef price (r = -.72). The third and final variable in the two-month equation which was found to be statistically questionable, retail pork price, was revealed to be correlated with per capita income (r = .68), wholesale beef price (r = .59), and fed marketings (r = .45). The correlation present between the variables displaying the poor test statistics and other variables in the two-month equation, coupled with the improvement in explanatory power witnessed with the inclusion of those variables, would seem to indicate that the poor test statistics can be at least partially attributed to the fact that the full impact of each of the variables in question is not measured in the parameter estimates for those variables. For the above reasons, omission of these variables could be expected to decrease forecast accuracy.

At a slaughter price mean of $31.99 per cwt. over the period April, 1968 through April, 1973, the standard deviation of price about the mean was $1.34. Residuals ranged from a high of $2.68 for the December, 1968, predicted value to a low of -$.05 in the October, 1971 prediction. For a better illustration of the model's forecasting ability, backcasts using projected values of the exogenous variables are plotted against actual price for the observation period in Figure 10. Deviations ranged from $0 to $4.50 in April, 1972 (time-scale value 47). Forecasts are

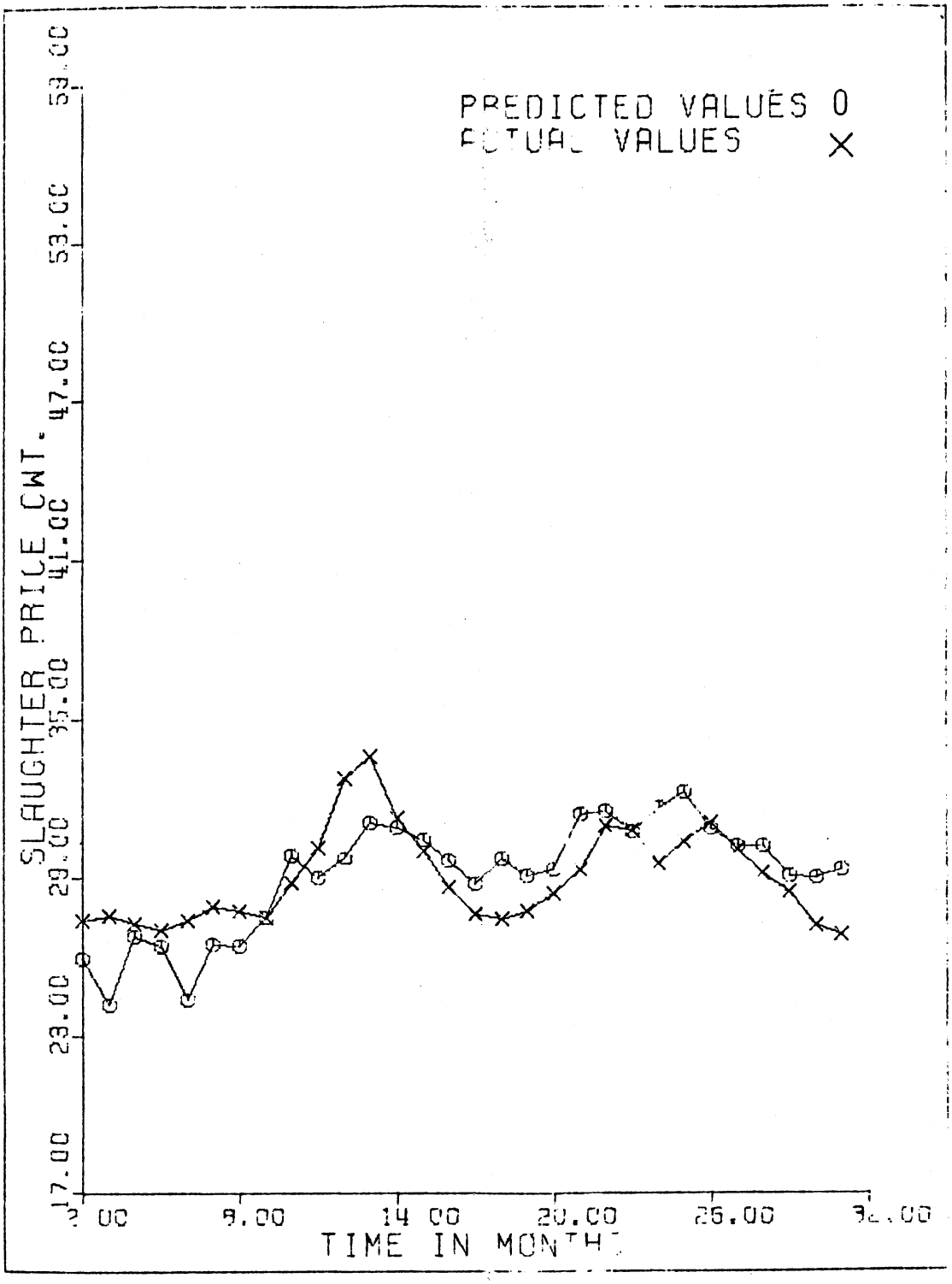

Figure 10. Backcasts and Actual Monthly Choice Steer Prices, Two-Month Model.

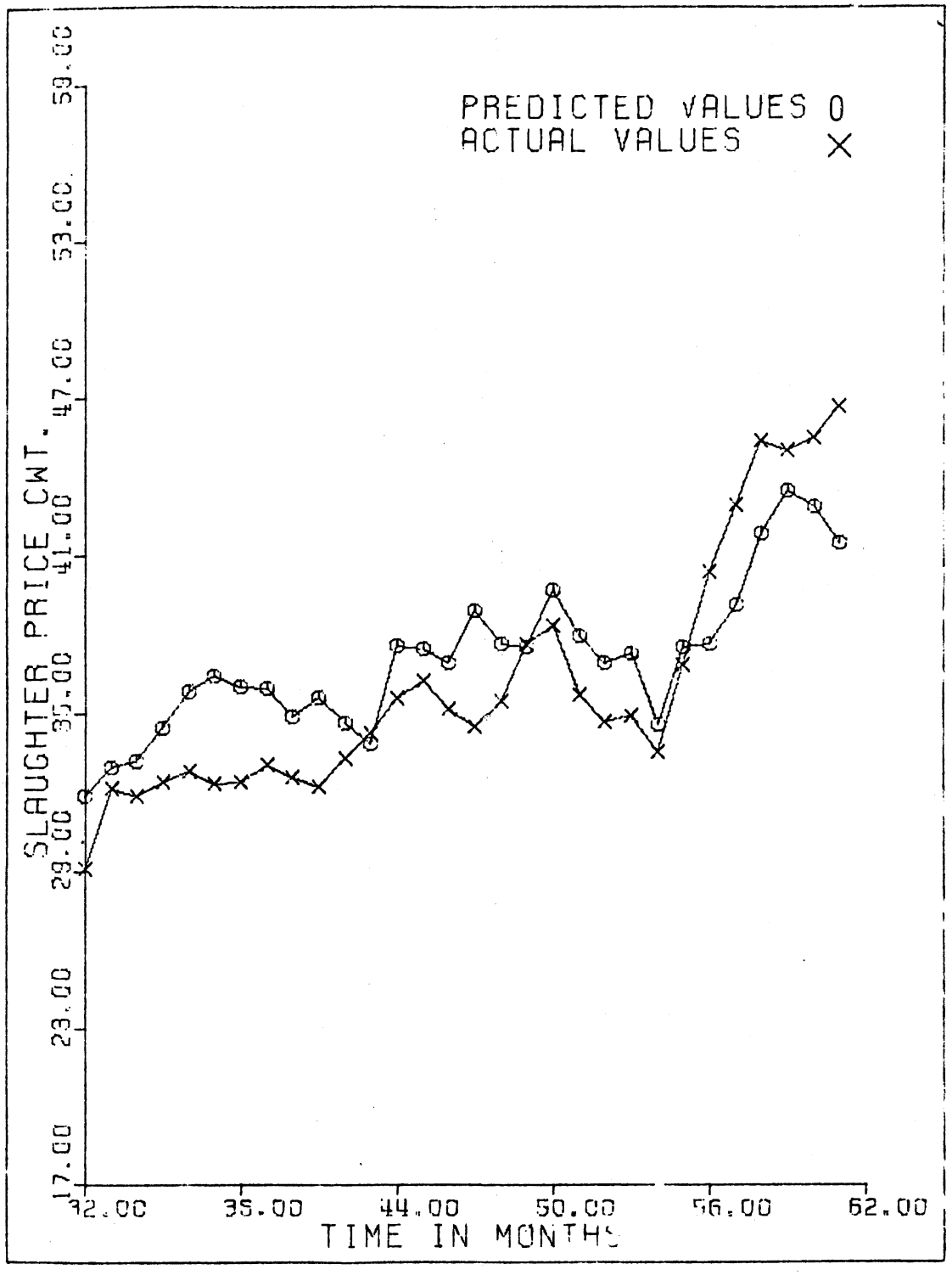

Figure 10. (Continued)

made from the base months of March and April, 1973 projecting two months into the future to May and June (time-scale values 60 and 61).

Three-Month Predictive Equations

The model designed to forecast price three months into the future consisted of the set of monthly dummy variables; all of the projected exogenous variables previously discussed; and the lagged exogenous variables representing wholesale beef price, retail beef price, and cold storage holdings of pork. Of all the non-binary exogenous variables, only three failed to be statistically significant at the .01 level or better: wholesale beef price (.27), retail beef price (.35), and pork storage (.35). Wholesale beef price was found to be correlated with fed marketings (r = .62), per capita income (r - .82) and retail beef price (r = -.76). Partial correlation coefficients calculated for retail beef price paired with each of the other exogenous variables revealed correlation with fed marketings (r = -.52), per capita income (r = -.67), and wholesale beef price (r = -.76). Similar reasoning to that employed in the selection of variables for both the one- and two-month models was relied upon in this case to justify retaining the variables.

The mean value of slaughter price in the three-month model was $32.11. The standard deviation of price about the mean line was calculated to be $1.38. Residuals ranged from a high of $2.94 for the December, 1968, predicted value to a low of $.00 in the October, 1968, prediction. To facilitate a better understanding of the predictive ability of the three-month forecasting model, please refer to Figure 11. Backcasts, using projected values of the exogenous variables, are

plotted against actual prices recorded during the observation period. Deviations ranged from $0 to $4.25 in March, 1973 (time-scale value 57). The last three coordinates plotted in Figure 11 represent true forecasts of price for the months May, June and July (time-scale values 59, 60 and 61) based on both the values of the exogenous variables projected and those lagged variables whose values were recorded in the base months of February, March and April, respectively. It will be noticed that the plot of actual values begins a rapid divergence from the predicted prices with the forecasted value for July 1973. Since the regression model attempts to estimate price under "typical" or "normal" marketing conditions, this divergence can be at least partially attributed to the a-typical effect of the federal government's "freeze" on beef prices imposed on March 27, 1973.

Four-Month Predictive Equations

The four-month predictive model was constructed using the set of monthly dummy variables; all of the projected exogenous variables employed in previously interpreted models; and the lagged exogenous variables representing retail beef price, pork storage, and percent of income spent on food. Each of the non-binary exogenous variables except the variables representing retail beef price, and percentage of income spent on food was found to be statistically significant at the .10 level or better. Retail beef price proved to be correlated with both per capita income ($r = -.68$) and percentage of income spent on food ($r = .66$). The percentage of income-spent-on-food variable was correlated with fed marketings ($r = -.68$), per capita income ($r = -.95$) and retail beef price ($r = .66$). The same reasoning employed in the models

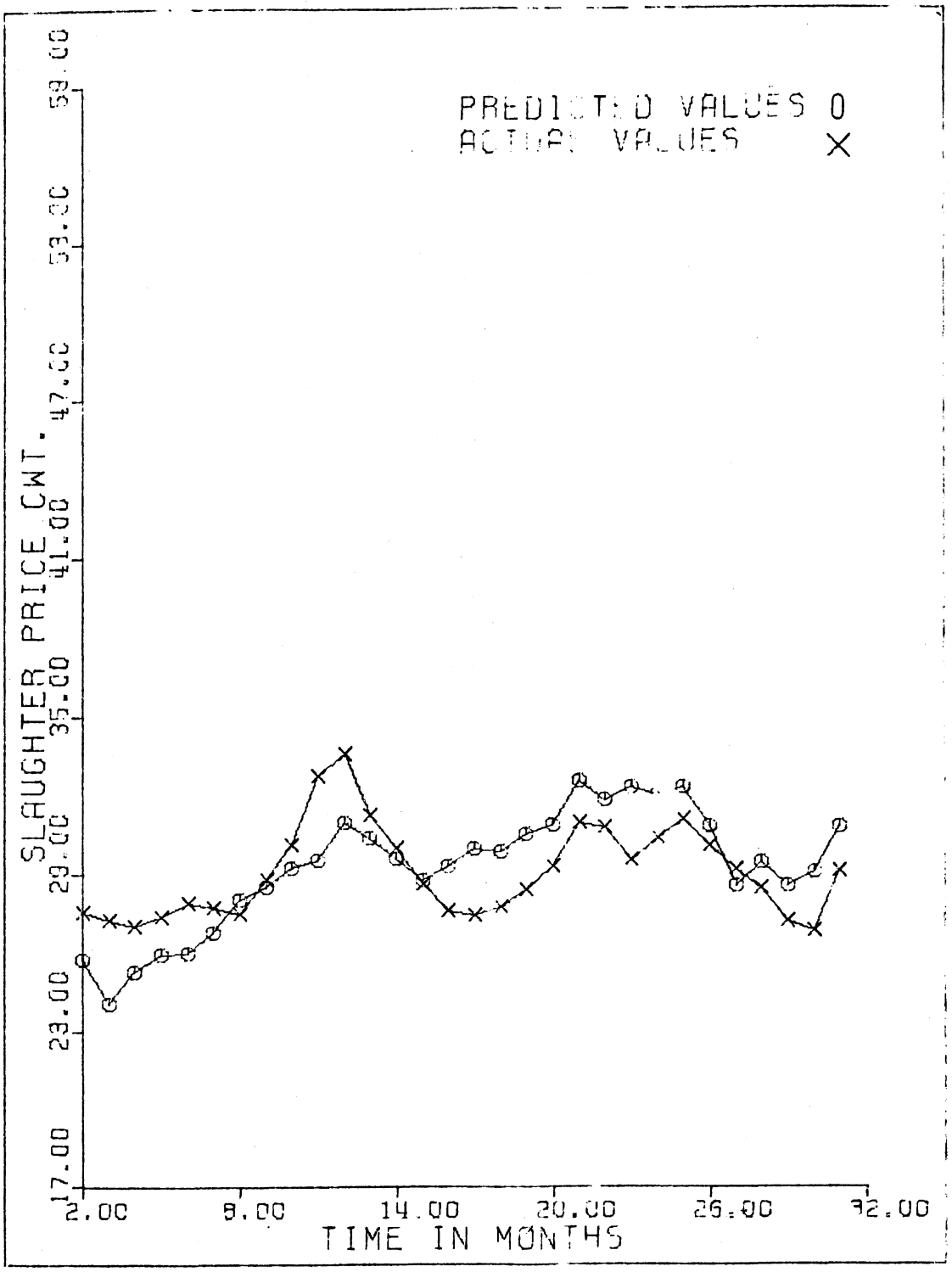

Figure 11. Backcasts and Actual Monthly Choice Steer Prices, Three-Month Model.

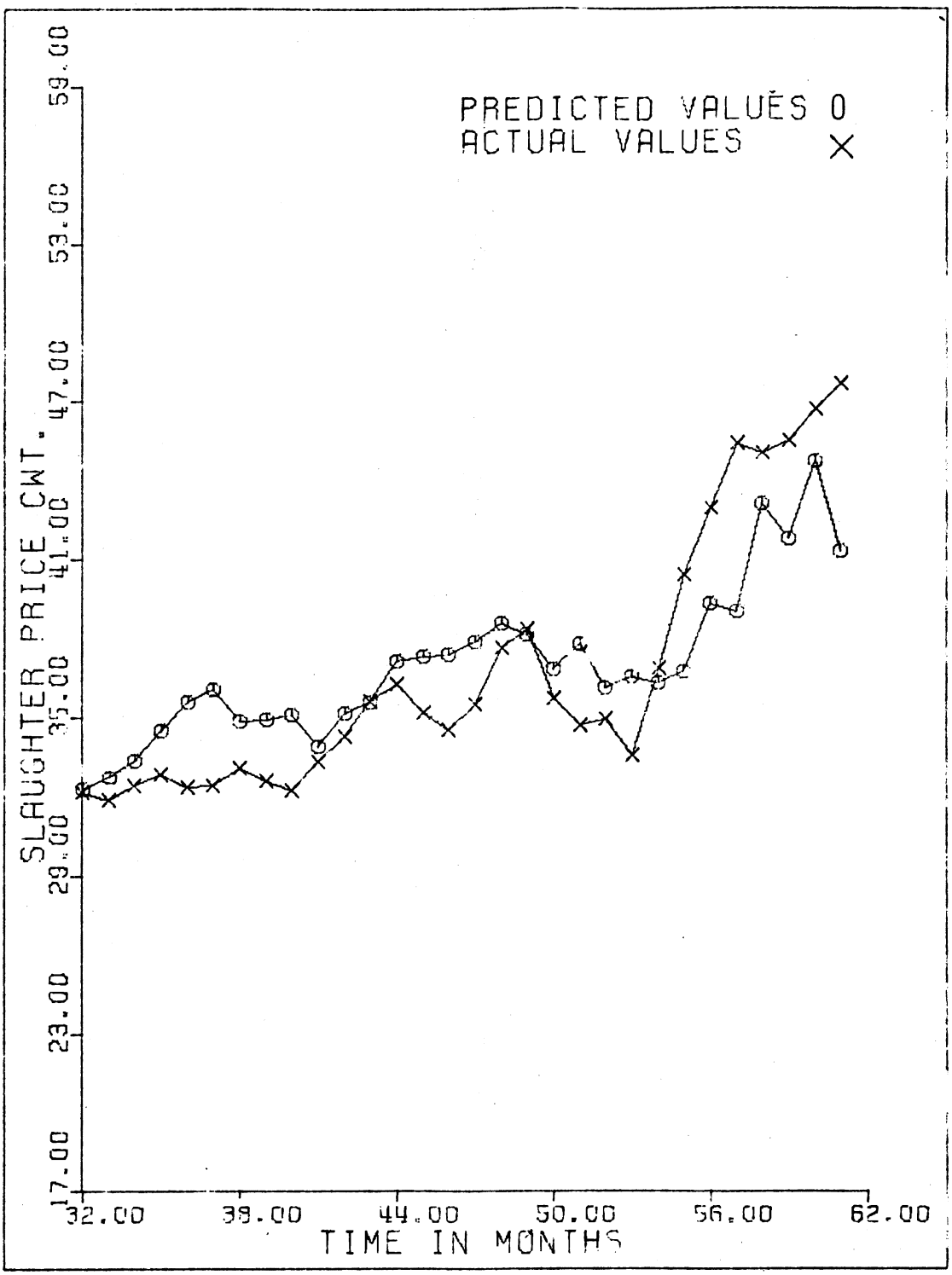

Figure 11. (Continued)

previously discussed was called upon to justify the retention of these variables.

The mean value of slaughter price in the four-month model was computed to be $32.17. The standard deviation was $1.36. Residuals ranged from a high of $2.75 for the December, 1968 predicted value to a low of $.01 in the April, 1970 prediction. Illustrations of the backcasted values using projected values of exogenous variables plotted against actual average monthly price are presented in Figure 12. Deviations range from $0 to $4.87 in March, 1973 (time-scale value 56). The last four coordinates plotted in Figure 12 represent forecasted values for the months of May, June, July, and August (time-scale values 58, 59, 60, 61) based on information observed in and projected to the base months of January, February, March and April, 1973, respectively. Actual prices begin to diverge rapidly from predicted prices starting in February, 1973 (time-scale value 55) and an even more rapid divergence begins with the four-month forecast for June after which not only the magnitude of price change is incorrectly anticipated but also the direction of change. Once again a partial explanation of this lies in the effects of government intervention in the normal marketing pattern of the fed beef economy.

Five-Month Predictive Equations

The model designed to predict price five months into the future employed the set of monthly dummy variables, all of the projected exogenous variable values and the lagged exogenous variables retail pork price and pork storage. All of the non-binary exogenous variables, except retail pork price, proved to be statistically significant at the

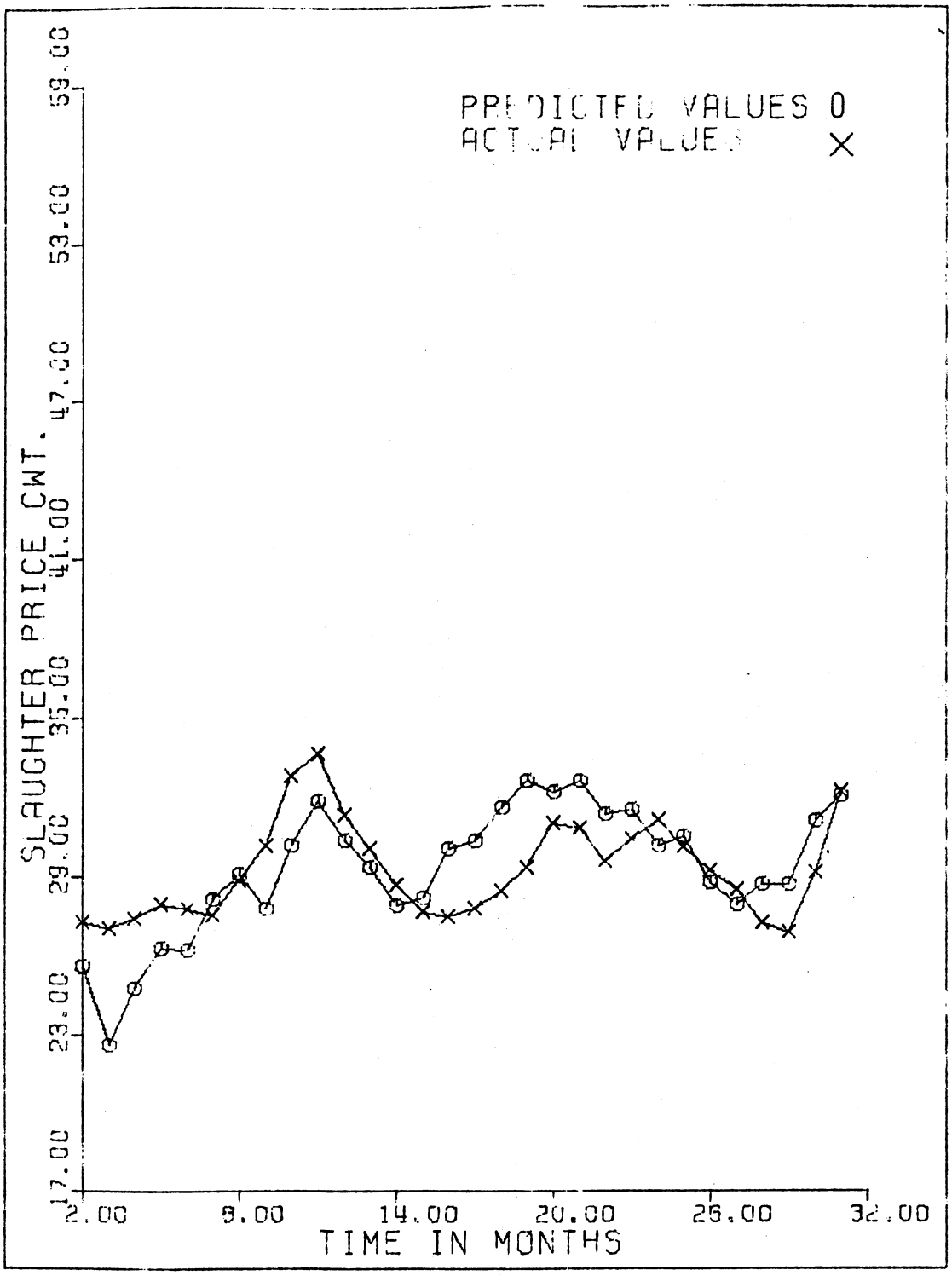

Figure 12. Backcasts and Actual Monthly Choice Steer Prices, Four-Month Model.

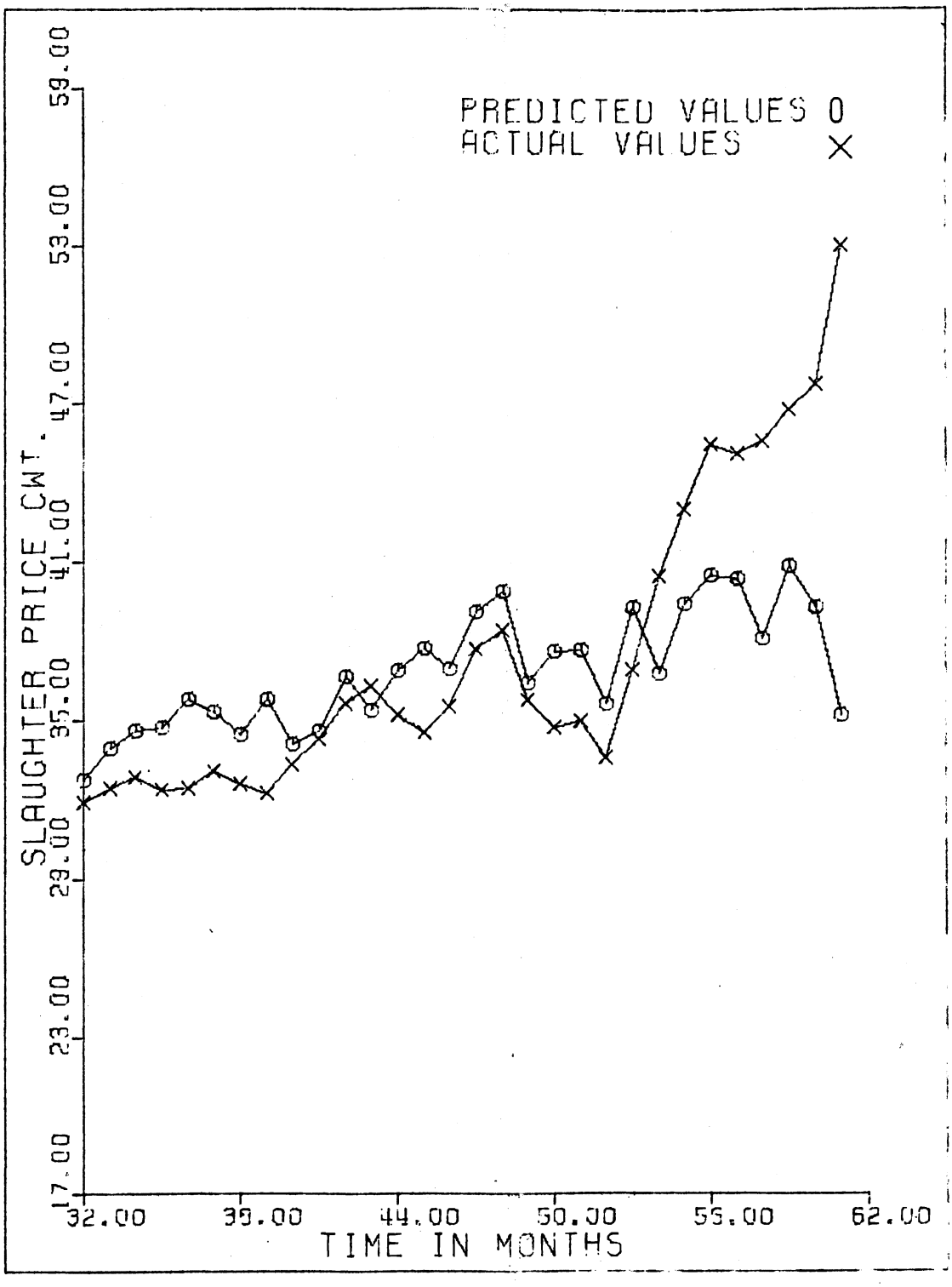

Figure 12. (Continued)

.05 level or better. Retail pork price was found to be correlated with per capita income (r = .58), which could explain the poor test statistic for that variable. For this reason, and because of the increase in explanatory power of the model with the inclusion of the retail pork price variable and its theoretical economic importance the variable was not deleted from the five-month model.

The five-month predictive model displayed a slaughter price mean of $32.26 and standard deviation of $1.32. Residuals ranged from $3.05 in the December, 1968 prediction to $.02 in the predicted value for February, 1969. Backcasts were computed for the months within the observation period by using projected values for the exogenous variables. Plots of the backcasted values versus actual values are presented in Figure 13 along with forecasts for May, June, July, August and September, 1973. It can be seen that the model begins to accurately predict the direction of change from August to September and substantial decreases in the magnitude of the forecast error are accomplished with the September forecast.

Six-Month Predictive Equations

The six month predictive model was constructed using the set of monthly dummy variables; all of the projected exogenous variables; and the lagged exogenous variables representing retail pork price, pork storage, and percentage of income spent on food. Each of these variables was found to be significant at the .05 level or better except the monthly dummy variables and the variable representing the percentage of income spent on food. The percent of income spent on food was found to be correlated with fed marketings (r = -.62), per capita income (r = -.95),

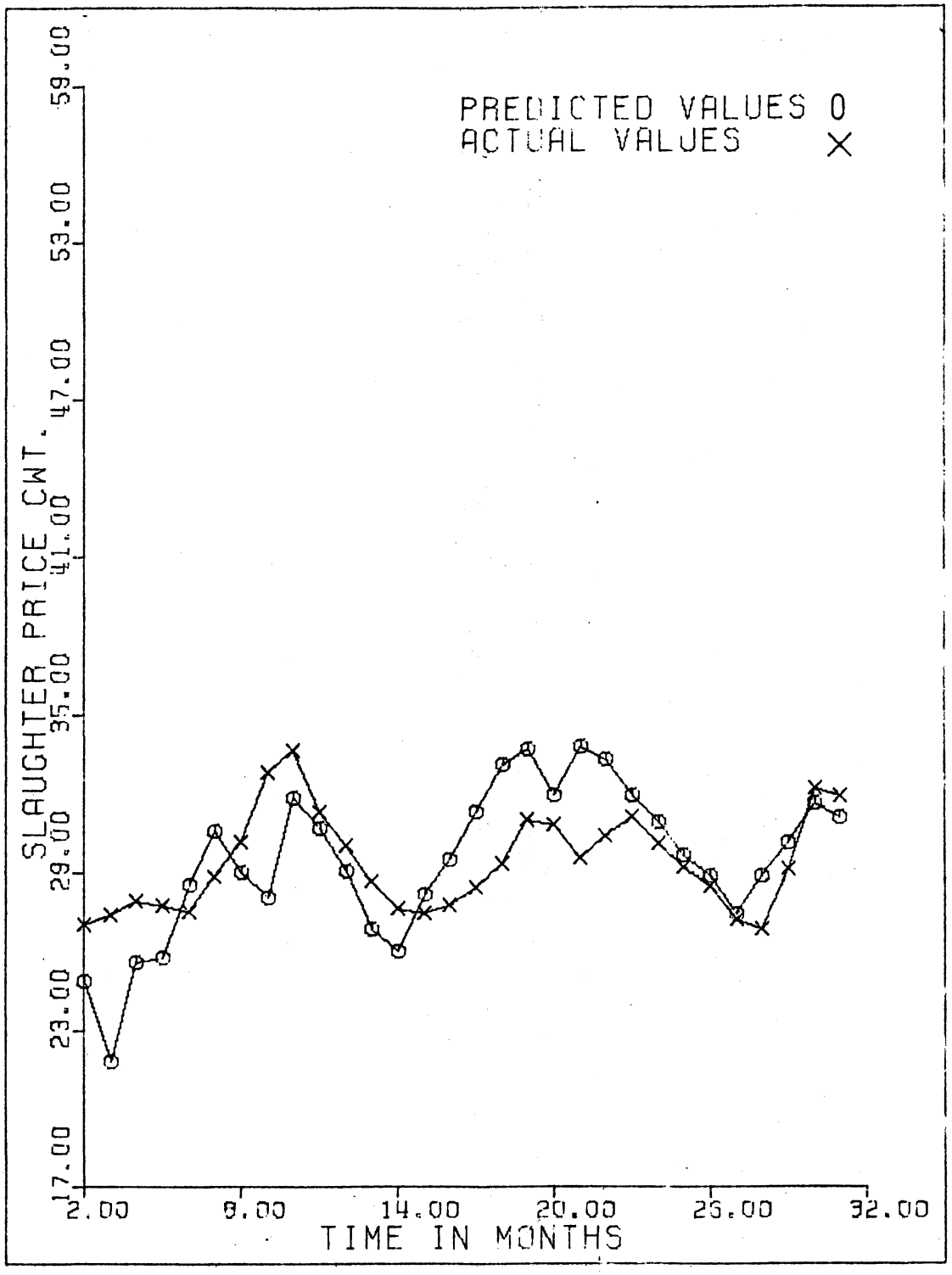

Figure 13. Backcasts and Actual Monthly Choice Steer Prices, Five-Month Model.

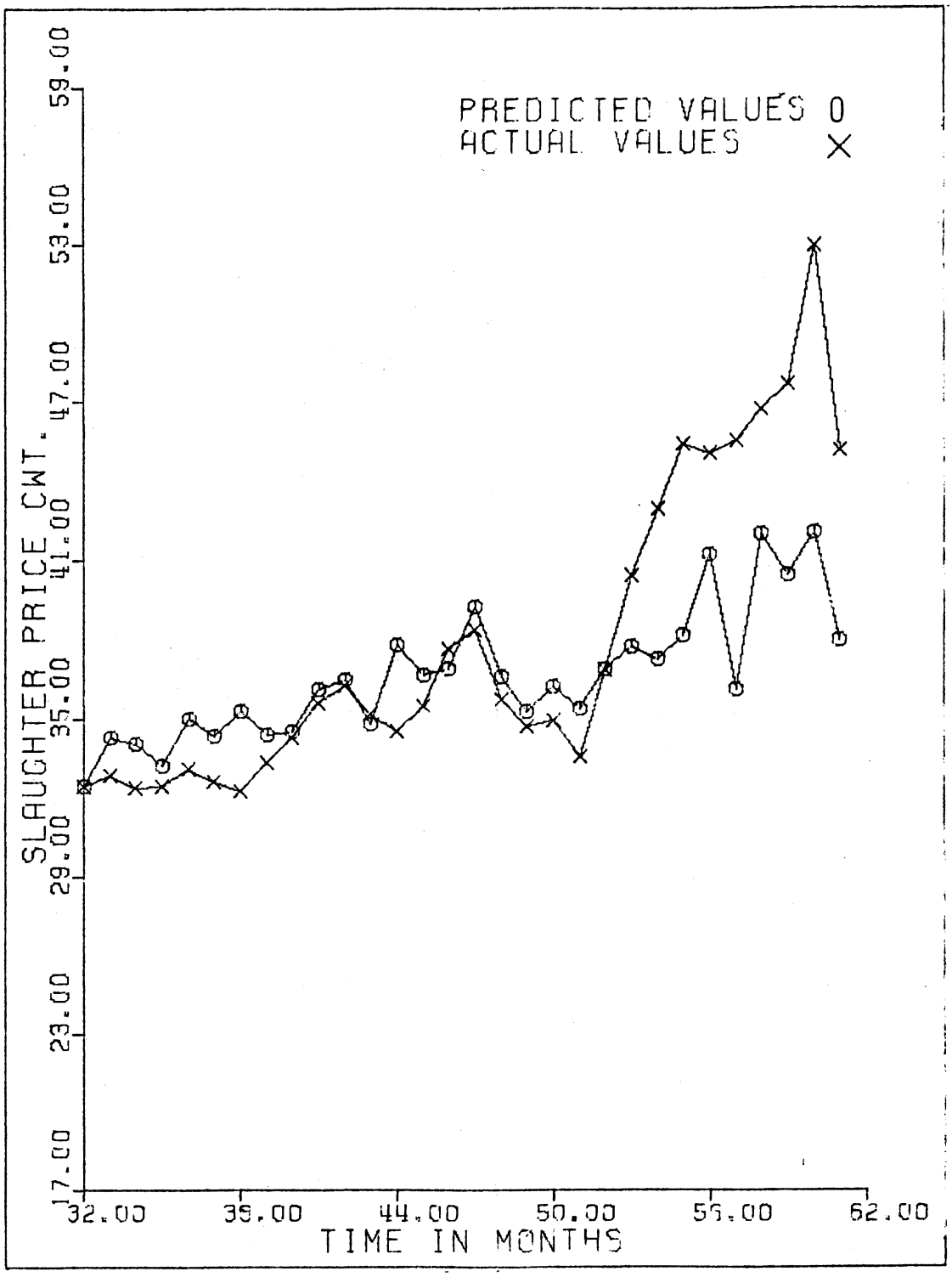

Figure 13. (Continued)

and retail pork price (r = -.57). For the same reasons cited in the five month model for retention of statistically marginal variables, the percentage of income-spent-on-food variable was not deleted from the six-month model.

Slaughter price mean for the model was $32.35, with standard deviation reported to be $1.28. Residuals ranged from a high of -$2.64 in the prediction for April, 1972 to a low of $.03 in the prediction for September, 1969. Backcasts were computed using projected exogenous variable values and are presented in Figure 14 along with plots of actual price. Deviations ranged from $0 to $8.25 in March, 1973 (time-scale value 54). The last six points on Figure 14 represent forecasted values for the months of May, June, July, August, September and October (time-scale values 56 through 61) based on data collected and variable values projected to the base months of November, 1972 through April, 1973. The forecasts for September and October register a significant improvement over the forecasted prices during the summer months prior to removal of the price freeze on beef.

Seven-Month Predictive Equation

The seven-month predictive model attempted to explain variations in price by incorporating as explanatory variables the set of monthly dummy variables; all of the projected exogenous variables; and the lagged exogenous variables representing retail pork price, pork storage and beef storage. Excluding dummy variables, all of the exogenous variables were deemed significant at the .05 level or better except the beef storage variable with a significance level of .18.

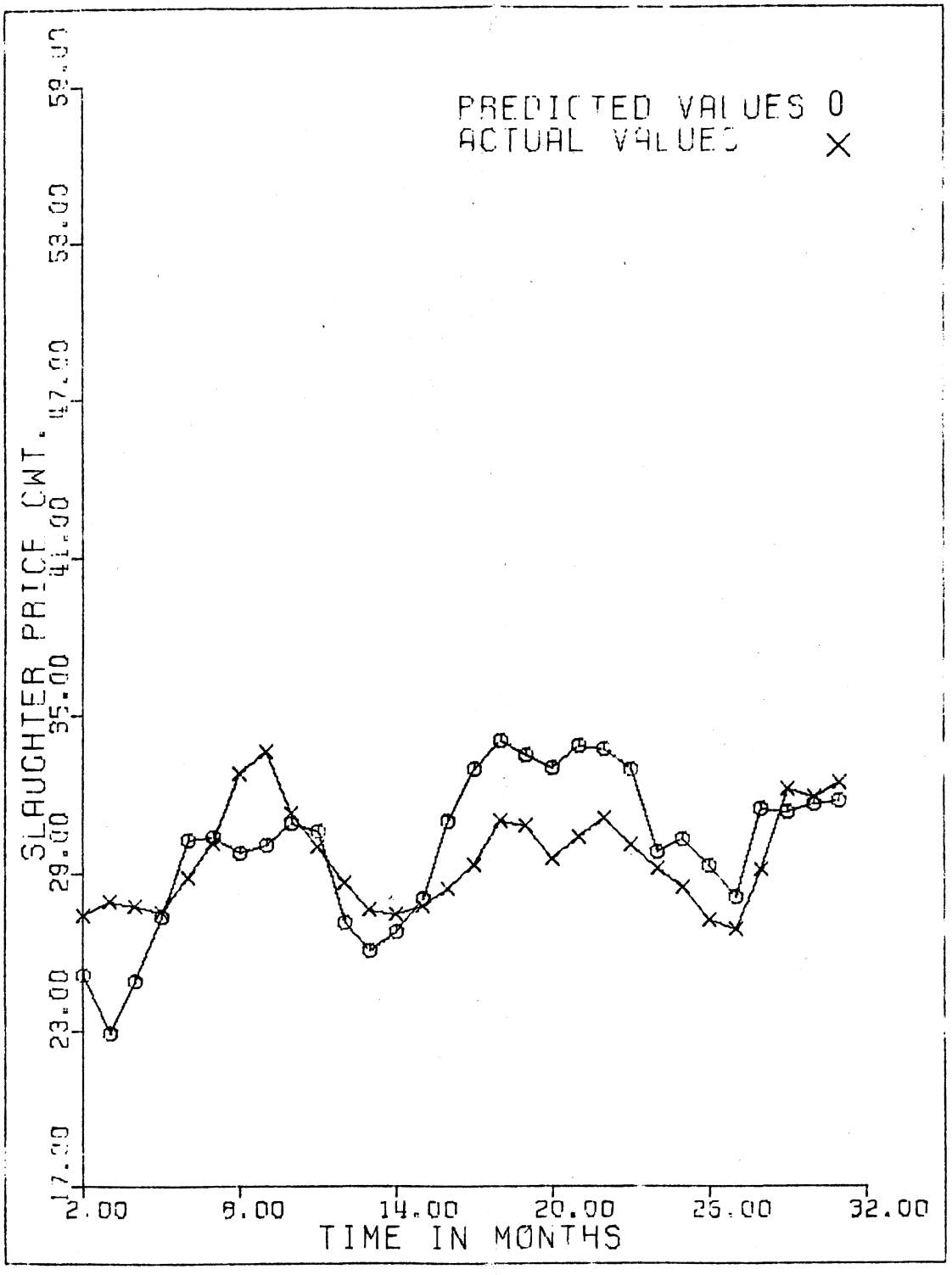

Figure 14. Backcasts and Actual Monthly Choice Steer Prices, Six-Month Model.

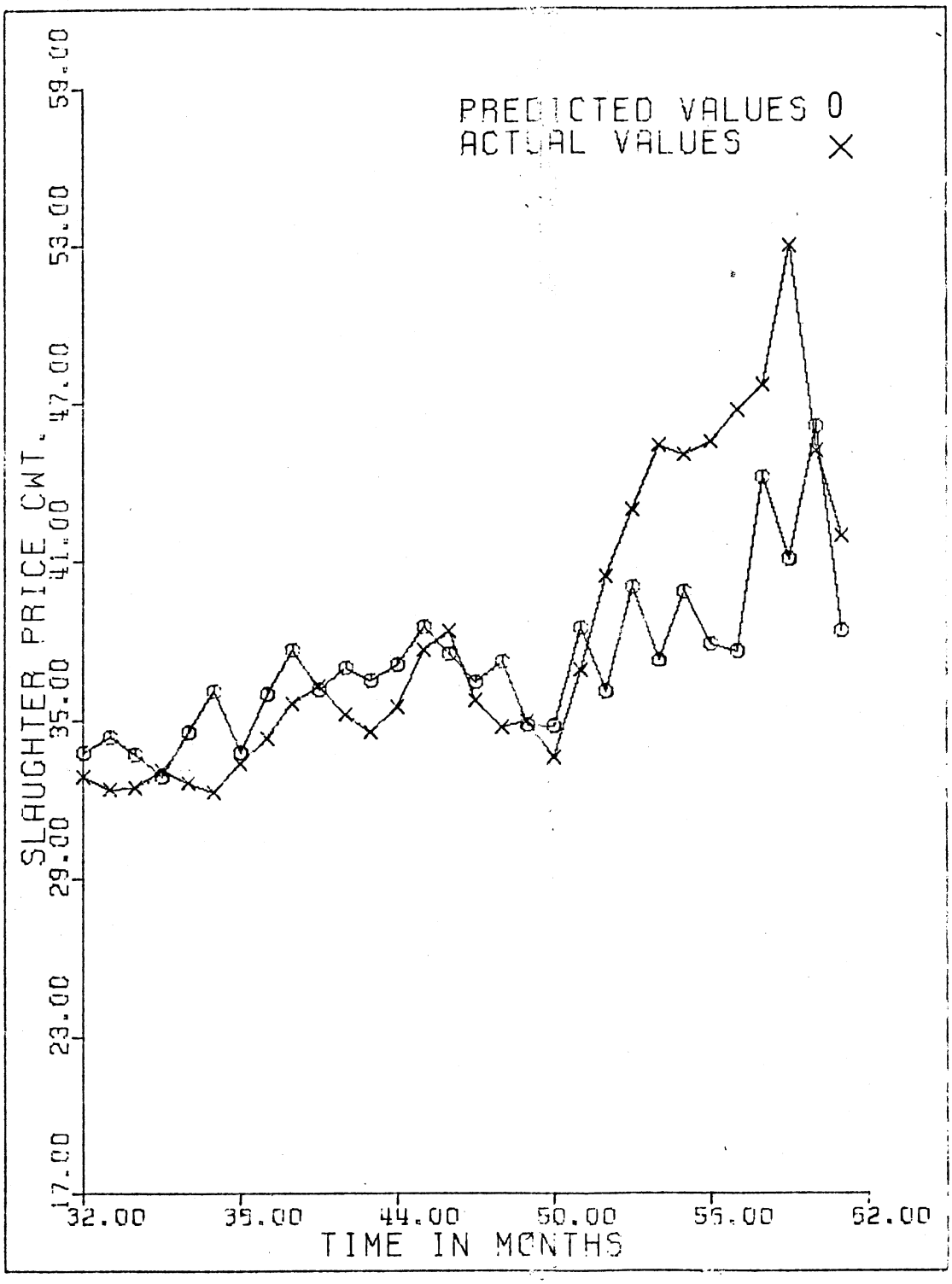

Figure 14. (Continued)

The seven-month model registered a slaughter price mean of $32.45 and a standard deviation of $1.33. Residuals ranged from a high of $2.29 in the April, 1969 prediction to a low of $.00 for July, 1972. Again, to more accurately illustrate the predictive ability of the model, backcasts were computed for the observation period using projected rather than actual values for the exogenous variables. Seven forecasts were made for the seven months immediately following the observation period. Illustrations of the backcasts and forecasts are contained in Figure 15. The last seven points in Figure 15 represent the forecasts. From these it can be seen that beginning with the September forecasts, the seven-month model regains its ability to correctly forecast the direction of price change. In addition, the magnitude of the forecast error is substantially diminished, shrinking from -$11.47 per cwt. in the August forecast to -$.85 in the seven-month forecast for October.

Eight-Month Predictive Equation

In the attempting to develop a model to forecast price eight months into the future the following variables were employed: the set of monthly intercept shifters, all of the projected exogenous variables, and the lagged exogenous variable beef storage. Excluding the set of dummy variables, all of the exogenous variables were found to be statistically significant at the .05 level or better, except pork production (.09) and beef storage (.16).

With a slaughter price mean of $32.54, the standard deviation was computed to be $1.37. Residuals spanned the range from $.00 in the September, 1969, prediction to $2.54 in the prediction for November of 1971. Once again, a more valid example of the model's forecast accuracy

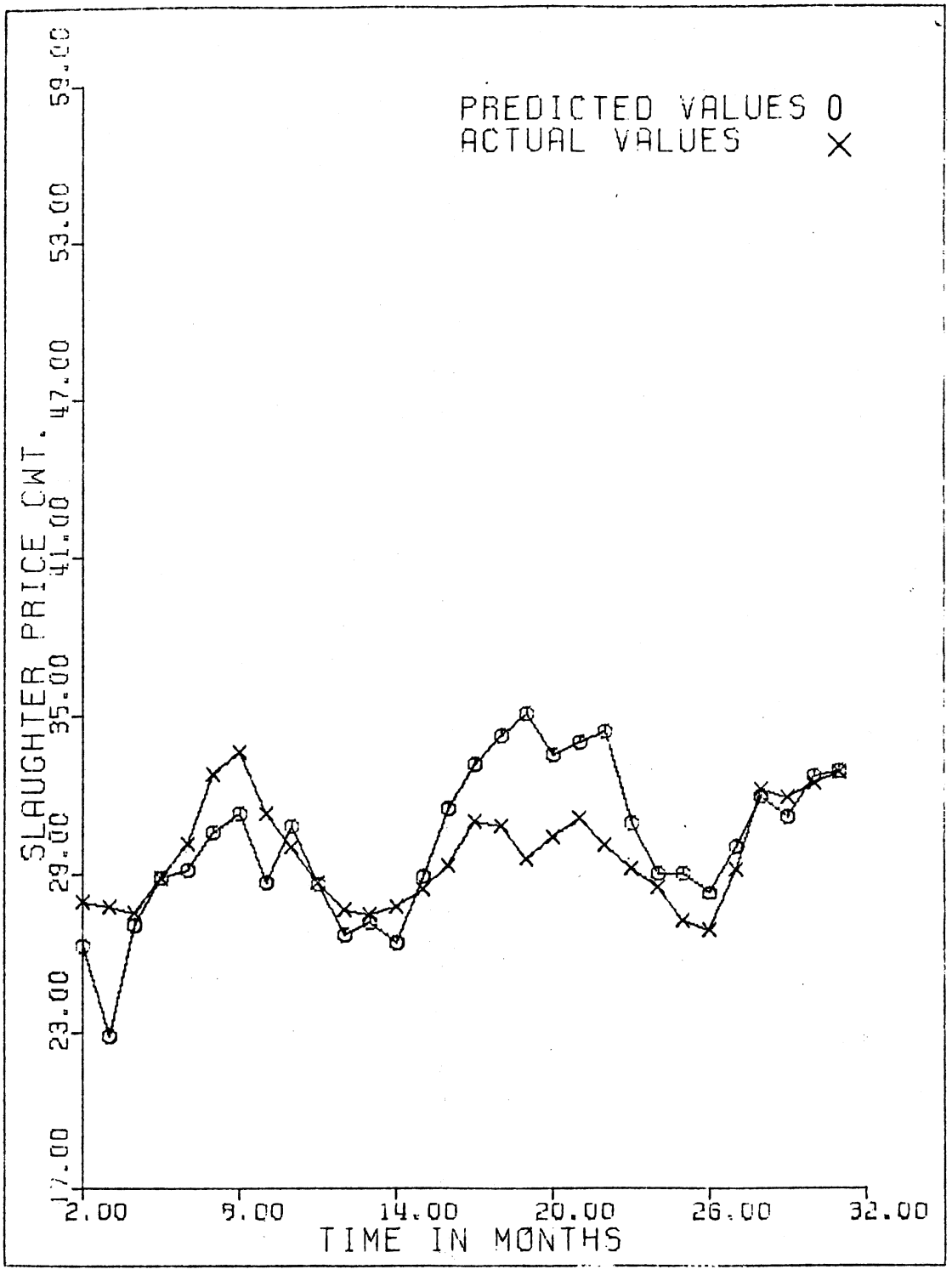

Figure 15. Backcasts and Actual Monthly Choice Steer Prices, Seven-Month Model.

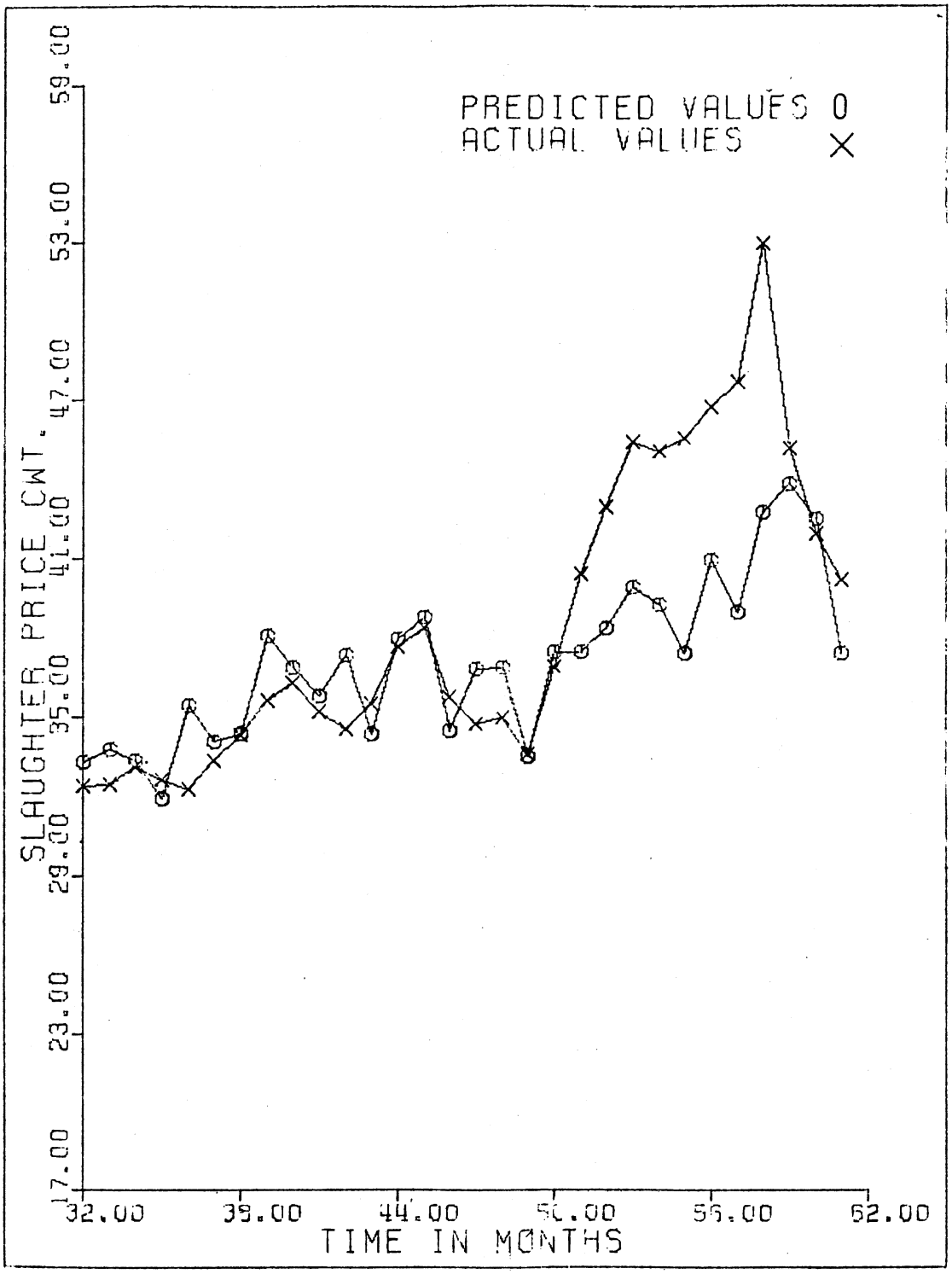

Figure 15. (Continued)

is illustrated in Figure 16, where the backcasts (using projected exogenous variable values) for the observation period, and forecasts for the eight months immediately following--May through December, 1973--are plotted against actual price. The eight month model appears to be regaining accuracy with the October forecast, underestimating by only $1.18 as compared to the eight-month forecast for August which missed by -$13.40.

Evaluation of the Models

The capacity of the models to accurately predict the price level has been illustrated in Figures 9 through 16. For decision purposes, the capacity of the model to accurately project the direction of price movement may be even more important.

Examination of Figures 9 through 16 reveals the models do, with minor exception, correctly depict the direction of price change. The 1973 period, during which the price freeze was in effect, is an obvious exception but the impact of such developments is not accounted for by the models. During the rest of the observation period, errors in predicting direction of change are relatively minor and usually last for only one of the "forecasted" months before the model again correctly calls the direction of change. Given this capacity and the magnitude of the deviations or "misses" in forecasted values as compared to the variability in actual prices, the models should prove useful to the real-world decision maker.

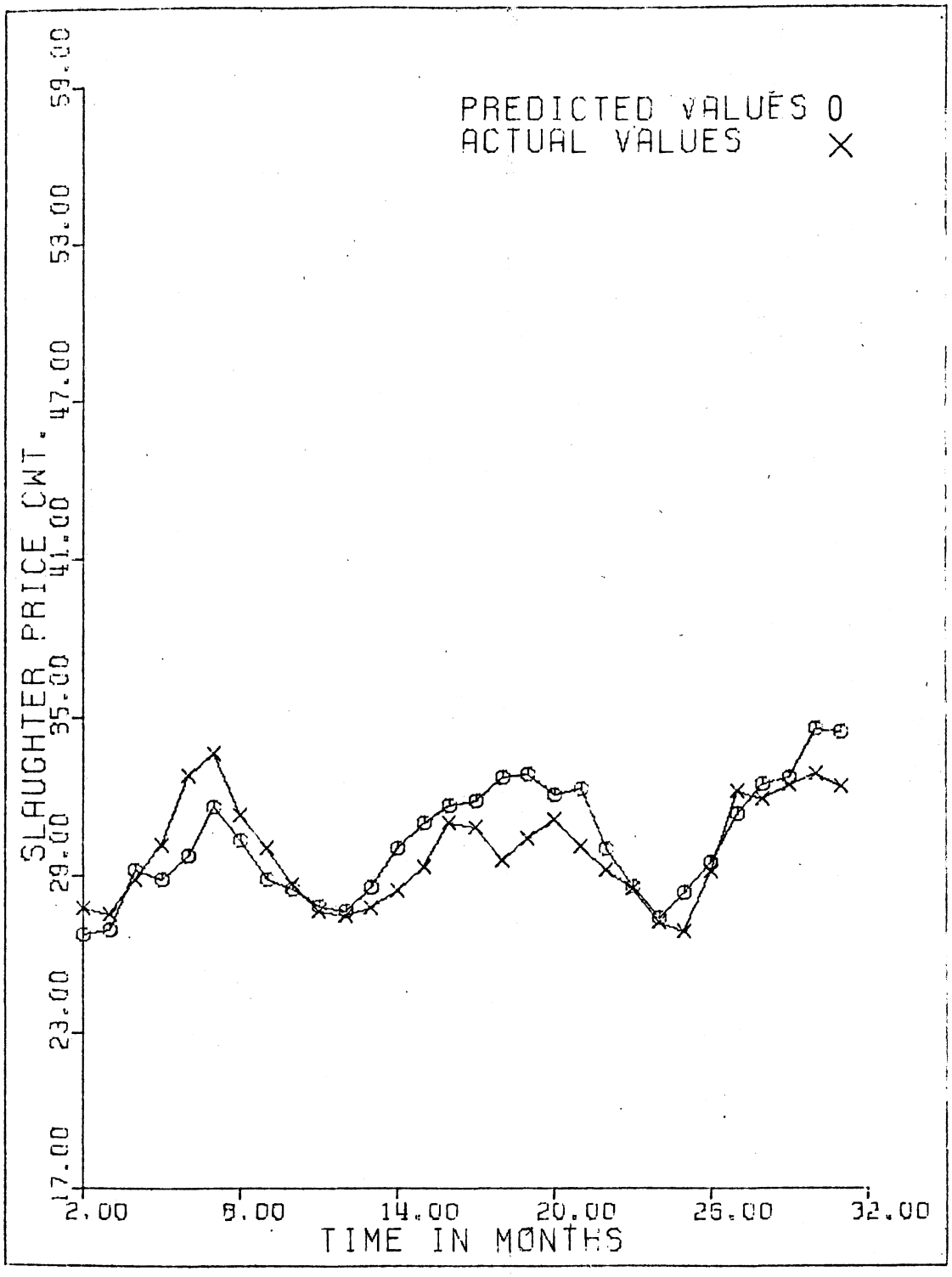

Figure 16. Backcasts and Actual Monthly Choice Steer Prices, Eight-Month Model.

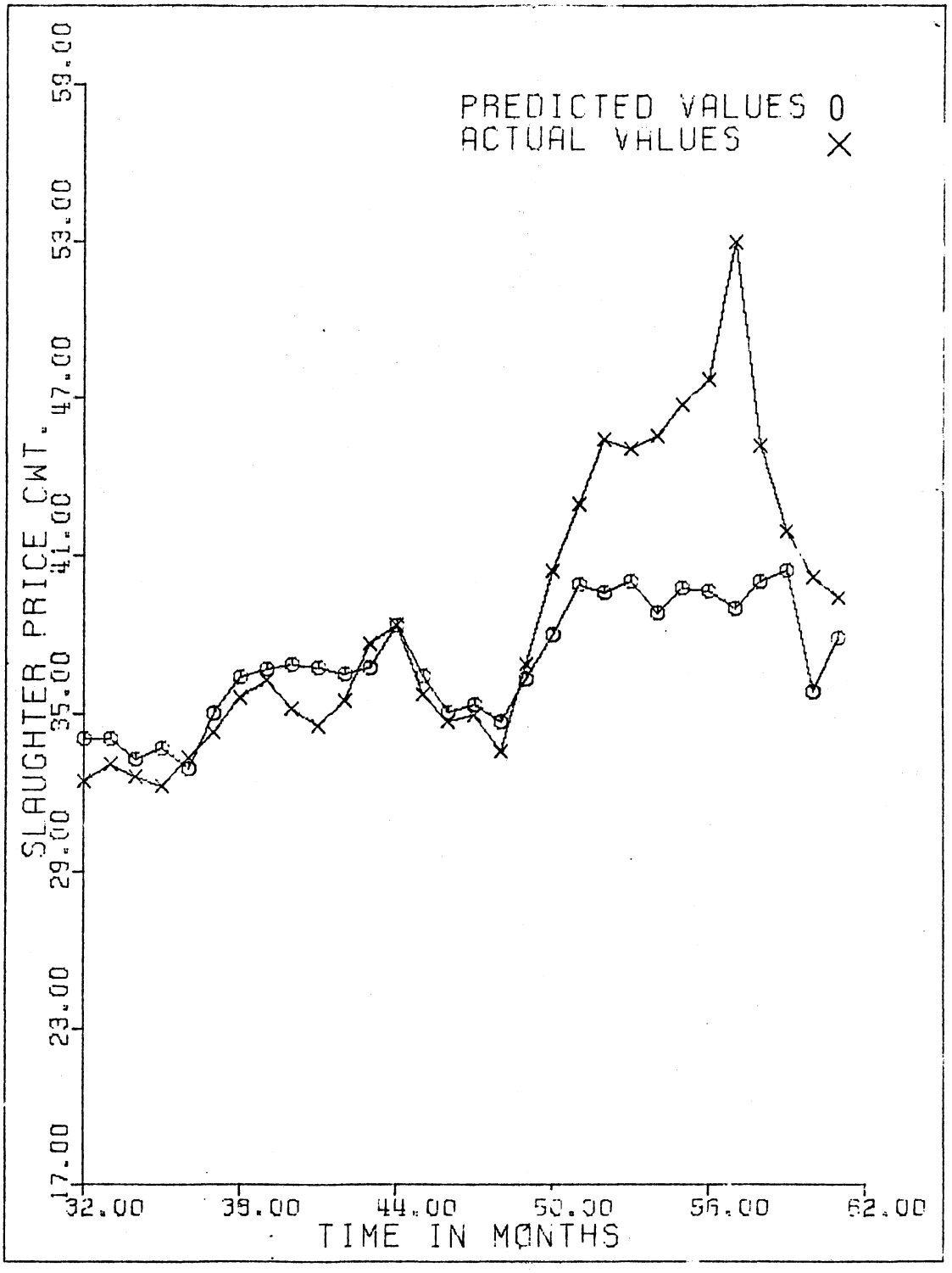

Figure 16. (Continued)

CHAPTER V

SUMMARY, CONCLUSIONS AND IMPLICATIONS

Summary

Firms at the feeder-packer level of the beef marketing chain are subject to high risk resulting from unfavorable changes in the cash price for fed steers. The high degree of price risk inherent in the industry increases the difficulty of the marketing decisions, promotes increased uncertainty in planning, and acts to shorten the planning horizon.

The objective of this research effort was to develop a short-run price forecasting model for fed steers which could provide industry participants with monthly price forecasts from one through eight months into the future. It was believed that reasonably accurate forecasts of fed steer prices would enhance the ability of market participants to solve the replacement problem and to more effectively make the hedging decision. To achieve this objective it was necessary to develop a separate forecasting model for each of the predictive intervals of one through eight months. In each of the models, three types of exogenous variables were employed: monthly dummy variables, variables to which price displays a lagged response, and variables to which price responds in concurrent time periods making it necessary to project the values of those variables. The monthly dummy variables were incorporated as a means of allowing the level of the regression line to shift from month

to month due to otherwise unspecified seasonal factors. Lagged exogenous variables were thoroughly examined in an attempt to discover variables whose values could be observed in the base month but whose impact on price would not reveal itself until a future month. It was felt that the potential for error in the price forecasts would be substantially diminished by the use of variables whose values did not have to be projected. However, with the identification of some of the most relevant causal factors in slaughter price fluctuations, the necessity of forecasting values for the exogenous variables could not be ignored. Such was the case with monthly per capita income, fed marketings, commercial pork production and cow slaughter.

The consistent patter of gradual increase in the data for both U. S. total personal income and population seemed to readily lend itself to prediction with the aid of simple trend analysis regressing each of the above mentioned variables on time in months. The analysis resulted in a model for income which had an R^2 of .987 and a model for population with R^2 equal to .997. The models were judged to be adequate forecasters of income and population over the period April, 1968 through April, 1973, and their results were combined to provide reliable forecasts of per capita income.

A somewhat larger problem was encountered in attempting to forecast monthly 23-state marketings of fed cattle. Eight separate models were developed using lagged exogenous variables to forecast monthly fed marketings from one through eight months into the future. The lagged variables were of three types: variables believed to be the primary determinants of the quantity of cattle which would be available for marketing in future months, variables intended to reflect the intensity of

placement and marketing motivation of cattle feeders, and monthly dummy variables included to account for the effects of otherwise unspecified seasonal factors by shifting the level of the regression line from month to month. The regression models resulted in relatively good fits over the observation period and produced forecasts of fed marketings judged acceptable for inclusion in the price model.

A simplified form of the same general approach was employed to forecast monthly commercial pork production. The number of hogs and pigs on farms quarterly was used in conjunction with a variable representing the number of fully utilized slaughter days to project pork production from one through eight months into the future. Each of the eight models displayed relatively good fits and greatly facilitated the projection of pork production based on information available in the current time period.

In observing the pattern of cow slaughter under federal inspection a definite seasonal pattern emerged. In a previous research effort the seasonal component of month-to-month variation was reported to be 66 percent of the total.[1] Therefore, the calculation of a seasonal index to use in forecasting monthly cow slaughter seemed to be an efficient use of research time and resources. Eight monthly cow slaughter forecasts were made from each of the 61 base months of the observation period to be used in the price forecasting models.

The final price model developed consisted of eight predictive equations, each designed to forecast the average monthly price of Choice 900-1100 lb. slaughter steers at Omaha in one of the eight monthly intervals. Each of the equations was composed of a particular combination of the three types of variables previously mentioned. In

conducting the regression analyses, actual values were used for both lagged exogenous variables and "projected" exogenous variables. Thus, the fits obtained reflect the ability of the model's exogenous variables to explain variations in the dependent series given perfect accuracy in projection of exogenous variable values. In order to more accurately illustrate the model's predictive ability, "forecasts" were made with each of the equations for the period April, 1968, through December, 1973. The "forecasts" were accomplished using projected values for exogenous variables which were expected to have an immediate impact upon price, rather than the actual values used in the regressions. For each predictive equation, graphs of predicted and actual price were presented to illustrate the model's capacity to project price levels and directions of price change when projected values of the exogenous variables were used in the computations.

Results of the Price Model

Each of the equations developed displayed predictive power judged to be acceptable and useful. Backcasts for the months of April, 1968, through April, 1973, follow the pattern of actual price extremely well. However, forecasts made outside the observation period begin to rapidly diverge from the pattern of actual price movements in May, 1973, and continue to widen throughout the summer. The divergence was at least partially precipitated by industry reaction to the price freeze on beef which was instituted in March of 1973. Holding in feedlots of cattle at or near slaughter weight curtailed slaughter throughout the summer and drove the price of live steers much higher than could have been anticipated under normal market conditions. With the removal of the

price freeze on September 12, 1973, the flow of slaughter cattle to market rapidly increased and forced price down. As the industry began to move back toward a normal marketing pattern, the accuracy of the price model was regained. The six-month predictive equation decreased the error of its forecasts from a high of -$11.91 per cwt. in August to +$.95 per cwt. in the forecast of September price. Similar examples can be witnessed in the forecasts produced by each of the eight equations. Due to the rapidity with which the model regained predictive accuracy when the cattle industry was allowed to move back toward normal marketing patterns, it is expected to remain a useful indicator of future price in months well beyond the original observation period, if conditions prevail which approximate a free market at the packer-feeder level of the beef industry.

Conclusions and Implications

It has been demonstrated that quantitative techniques can be combined with economic theory and an investigation of the interrelationships among the variables which represent the primary determinants of supply and demand for beef to produce reasonably accurate forecasts of monthly slaughter steer price as far as eight months into the future. The forecasts have the potential to reduce the price risk associated with the cattle feeding enterprise. The complexity of the replacement problem can be reduced to manageable proportions by facilitating the reliable calculation of expected net revenue from a replacement lot of cattle.[2] In addition, selection of the proper hedging strategy can more easily be accomplished, thereby decreasing the variance and increasing the mean of net returns.[3]

In the process of developing the price forecasting model, regression models to forecast both monthly, 23-state fed marketings, and monthly commercial pork production were developed. These models generated accurate forecasts and have the potential to serve as useful business management tools for industry independently of their use in the price model. In addition, the predictive accuracy achieved by the pork production model establishes it as a first step toward the development of a model to predict monthly price of slaughter hogs.

The main obstacle to increased forecast accuracy at this time is the accurate projection of those exogenous variables which appear to have the most substantial impact on slaughter steer price during the time period in which the variable values are first observed. The areas in which further research seems to have the greatest potential for increasing the accuracy of price forecasts is in the development of more sophisticated models to accurately project monthly commercial pork production and cow slaughter.

FOOTNOTES

[1]John T. Larson, Seasonality of the Cattle Market, ERS-468 (Washington, D. C., January, 1971), p. 27.

[2]Kenneth E. Nelson and Wayne D. Purcell, "A Quantitative Approach to the Feedlot Replacement Decision," Southern Journal of Agricultural Economics, Vol. No. 4 (July, 1972), pp. 143-149.

[3]David Holland, Wayne D. Purcell and Terry Hague, "Mean-Variance Analysis of Alternative Hedging Strategies," Southern Journal of Agricultural Economics, Vol. 4 (July, 1972), pp. 123-128.

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