COSTS, LOSS, AND FORECASTING ERROR: AN EVALUATION OF MODELS FOR BEEF PRICES

Thesis for the Degree of Ph. D. MICHIGAN STATE UNIVERSITY LLOYD DOUGLAS TEIGEN 1973



This is to certify that the

thesis entitled

Costs, Loss, and Forecasting Error: An Evaluation of Models for Beef Prices

presented by

Lloyd Douglas Teigen

has been accepted towards fulfillment of the requirements for

Ph.D. degree in Agricultural Economics

Major professor

Date December 7, 1972

O-7639



ABSTRACT

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By

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The problem which is addressed in this thesis is stated in the form of one theoretical and one empirical question. The theoretical question is what is an appropriate measure to evaluate the loss which results from incorrect forecasts when the firm using them places complete reliance in the information provided? Related to this is the question of how other measures of forecasting error are related to this measure. The empirical question relates to the relative performance of four means of generating forecasts for beef cattle prices, namely econometric models, trend models, price difference models, and the futures market price. The hypothesis which is tested is that performance is proportional to the information contained in the forecasting method (and hence to the cost of developing the forecast).

The theoretical section consists of the derivation of the following theorem: If the output price of a single product firm with a homogeneous production function and predetermined input prices is being forecast, then the loss (in the sense of the difference between actual and maximum realizable profits) due to forecasting error is proportional to $(r^{1+n} - (1+n) r p^n + n p^{1+n})$,

where r is the realized price, p is the forecast, and n is the elasticity of the firm's short run supply curve. By factorization, this loss function is shown to be related to the quadratic loss function which forms the basis for many widely used measures of forecasting performance.

The procedure followed in the empirical analysis consisted of four steps. The first of these was to choose the econometric models to be evaluated, using the criteria that they were published, accessible, and recent enough that their structures could be used for forecasting. Those selected were developed by Hayenga and Hacklander (1), Myers (2), Trierweiler and Hassler (3), Crom (4), and Unger (5). The second step in the process was to estimate trend models (both polynomial and trigonometric) for all of the price series used in the econometric models over sample periods identical with those of the corresponding econometric models. The third step was to invert the structural forms of the econometric models and calculate the forecasts implied by the econometric and other models for the test sample period of January 1965 to December 1970. Finally, the forecasts were evaluated over this period using a number of alternative performance criteria: Those used were the cost derived average loss measure derived in the theoretical section of the thesis, mean squared error, both of Theil's inequality measures U₁ and U₂, the number of incorrect predictions of change (turning point errors), absolute moment measures corresponding to the first through fourth absolute sample moments of the forecasting errors, the average relative error of forecast, the correlation of the forecast with the realization, the slope of the linear regression

equation of the forecast on the realization (of the form r = a + b p + u, where r is the realization, p is the prediction, and u is a disturbance term), and finally the bias, or average error of forecast when the sign of the error is accounted for.

The theoretical findings of this study were that the cost derived loss function is quadratic in the case where the supply elasticity is one, and contains a quadratic factor when the supply elasticity is an integer greater than one. A number of consistencies and inconsistencies were determined to exist among the rankings of the forecasts derived by the different performance measures: The mean squared error ranked consistently with the cost derived loss measure and with Theil's U₂ statistic, and adjacent moment measures exhibited consistent (but not transitively consistent) rankings of the forecasting performance of the models. It was observed that the correlation and the number of turning points missed gave rise to rankings which were not consistent with those of any other measure of performance.

The empirical findings of the study fall into two categories -the stability of the dynamic econometric models used in this analysis
and a comparison of all the means of generating forecasts on a onestep-ahead basis. The conclusion regarding the stability of the
models was that both the monthly and quarterly dynamic models indicated some degree of instability.

Comparing the alternative maintained hypotheses' forecasting performance, it was found that the polynomial trend model diverged shortly after the close of the sample period for estimation, the trigonometric trend model performed about as well as the econometric

models during the test period, correcting the trigonometric trend model for serial correlation of disturbances improved its forecasting performance substantially and that the overall best performing forecasting methods consisted of projecting either the current cash price or the corresponding futures price as the price to prevail in the forecast period.

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COSTS, LOSS, AND FORECASTING ERROR: AN EVALUATION OF MODELS FOR BEEF PRICES

Ву

Lloyd Douglas Teigen

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Agricultural Economics

1973

(g 30) 1/2

ACKNOWLEDGEMENTS

I gratefully acknowledge the guidance, intellectual stimulation, and encouragement which Robert Gustafson gave me throughout my stay at Michigan State as my major professor. The freedom he allowed me in the preparation of this thesis made this a challenging, if sometimes frustrating, experience. His suggestions often were what were needed to overcome the obstacles and always directed my efforts towards their eventual solution.

The contributions, both joint and separable, to my educational program and professional development made by Lester Mander-scheid, Marvin Hayenga, James Ramsey, and James Stapleton, as members of my guidance committee, and also by Roy Black, who served on my thesis committee are recognized with sincere appreciation.

The support contributed to my program by the Agricultural Economics Department in the form of computational facilities and secretarial assistance, as well as direct financial support through a research assistantship is acknowledged with grateful appreciation. The programming assistance rendered by Daniel Tsai deserves explicit recognition for his ability to quickly implement the procedures involved in this research with a minimum of detailed instructions.

The personal contribution and sacrifice on the part of my wife and daughter is most graciously acknowledged, and it is to them that this thesis is dedicated.

TABLE OF CONTENTS

List	of I	ables	v
List	of F	'igures	хi
I.	INT	RODUCTION	1
	A.	Setting	1
	В.	Object ives	2
	C.	Literature Review and Research Approach	3
II.	THE	ORY OF FORECAST EVALUATION	9
	A.	Forecasting as a Decision Problem	9
	В.	Forecasting for a Firm	13
	C.	Analysis of the Cost Derived Loss Function	17
	D.	Measures of Forecast Performance	20
III.	DIS	CUSSION OF THE MODELS FOR BEEF PRICES	31
	A.	Overview of the Chapter	31
		1. Econometric Models	33
		2. Trend Models	34
		3. Price Difference Models	36
		4. Futures Market Price	37
	В.	The Econometric Models	39
		1. Hayenga-Hacklander Monthly Model	43
		2. Myers Monthly Model	43
		3. Trierweiler-Hassler Monthly Model	47
		4. Crom Quarterly Model .	48
		5. Unger Annual Model	49
	С.	The Trend Models	49
		1. Taylor Series Approximation	53
		2. Fourier Series Approximation	54
		3. Estimates of the Trend Equations	58
		 Corresponding to the Hayenga- 	
		Hacklander Model	59
		b. Corresponding to the Myers Model	64
		c. Corresponding to the Trierweiler-	
		Hassler Model	72
		d. Corresponding to the Crom Model	73
		e. Corresponding to the Unger Model	86
	D.	The Price Difference Models	91
	E.	The Futures Market Price	94

IV.	EMP	IRICAL EVALUATION OF THE FORECASTING MODELS	100
	Α.	Stability of the Econometric Models	100
	В.	One-Step-Ahead Performance of the Competing	
		Forecasting Models	107
		1. The Sample Period	107
		2. Divergence of the Polynomial Trend Models	108
		3. Tabulation of the Performance Statistics a. Variables in the Hayenga-Hacklander	110
		Model	112
		b. Variables in the Myers Model	115
		c. Variables in the Trierweiler-Hassler	
		Mode1	115
		d. Variables in the Crom Model	126
	_	e. Variables in the Unger Model	133
	С.	Effect of Lead Period on Forecasts Based on	
		Futures Market Price and Price Difference	100
	_	Models	138
	D.	Summary	143
V.	SUM	MARY AND CONCLUSIONS	1 45
	A.	Summary and Conclusions	145
		1. Theoretical	145
		2. Empirical	153
	В.	Implications	160
	С.	Recommendations for Further Research	163
VI.	BIB	LIOGRAPHY	167
VII.	APP	ENDIX	174
	Α.	Observations Regarding the Analysis of and the	
		Data for the Econometric Models	174
		1. Analysis of the Econometric Models	174
		2. Data Generation, Manipulation, and	
		Fabrication	180
	В.	Appendix Tables	188
	_,	1. Data for, and Performance of, the	
		Econometric Models 2. Structural Forms of the Econometric	
		Models Used	
		3. Reduced Form Equations Corresponding to	
		THE MVETS STYLICTURAL MODEL	

LIST OF TABLES

Tab le		Page
1.	Measures of Forecasting Accuracy	29
2 a .	Characteristics of Econometric Models under Consideration	40
2ь.	Summary of Price Variables in Econometric Models under Consideration	41
3.	Estimated Polynomial Trend Equations Corresponding to Hayenga-Hacklander Model	60
4.	Estimated Trigonometric Trend Equations Corresponding to Hayenga-Hacklander Model	62
5.	Estimated Trigonometric Trend Equations Corresponding to Hayenga-Hacklander Model	63
6.	Estimated Polynomial Trend Equations Corresponding to Myers Model	66
7.	Estimated Polynomial Trend Equations Corresponding to Myers Model	67
8.	Estimated Polynomial Trend Equations Corresponding to Myers Model	68
9.	Estimated Trigonometric Trend Equations Corresponding to Myers Model	69
10.	Estimated Trigonometric Trend Equations Corresponding to Myers Model	70
11.	Estimated Trigonometric Trend Equations Corresponding to Myers Model	71
12.	Estimated Polynomial Trend Equations Corresponding to Trierweiler-Hassler Model	74
13.	Estimated Polynomial Trend Equations Corresponding to Trierweiler-Hassler Model	7 5
14.	Estimated Trigonometric Trend Equations Corresponding	76

15.	to Trierweiler-Hassler Model	77
16.	Estimated Trigonometric Trend Equations Corresponding to Trierweiler-Hassler Model	78
17.	Estimated Polynomial Trend Equations Corresponding to Crom Simulation Model	80
18.	Estimated Polynomial Trend Equations Corresponding to Crom Simulation Model	81
19.	Estimated Polynomial Trend Equations Corresponding to Crom Simulation Model	82
20.	Estimated Trigonometric Trend Equations Corresponding to Crom Simulation Model	83
21.	Estimated Trigonometric Trend Equations Corresponding to Crom Simulation Model	84
22.	Estimated Trigonometric Trend Equations Corresponding to Crom Simulation Model	85
23.	Estimated Polynomial Trend Equations Corresponding to Unger Model	87
24.	Estimated Polynomial Trend Equations Corresponding to Unger Model	88
25.	Estimated Trigonometric Trend Equations Corresponding to Unger Model	89
26.	Estimated Trigonometric Trend Equations Corresponding to Unger Model	90
27.	Forecasts of Choice 900-1100 lb. Steers at Chicago, 1965 to 1970	113
28.	Forecasts of U.S. No. 2-3 Grade, 200-220 lb. Barrows and Gilts at Chicago, 1965 to 1970	114
29.	Forecasts of Deflated Monthly Retail Price of Beef in Urban Areas, 1965 to 1970	116
30.	Forecasts of Deflated Prices of All Grades of Steers Sold Out of First Hands in Chicago, Omaha, and Sioux City (Weighted Average), 1965 to 1970	117
31.	Forecasts of Deflated Average Retail Price of Frying Chickens in Urban Areas, 1965 to 1970	118
32.	Forecasts of the Monthly Deflated Retail Price of Pork in Urban Areas, 1965 to 1970	119

33.	Forecasts of the Eight Market Weighted Average Deflated Price of Barrows and Gilts, 1965 to 1970	120
34.	Forecasts of Choice 600-700 lb. Steer Carcasses at Chicago, 1965 to 1970	121
35.	Forecasts of the Price of 900-1100 lb. Choice Steers at Omaha, 1965 to 1970	122
36.	Forecasts of U.S. Nos. 1-3, 220-240 lb. Barrows and Gilts at Omaha, 1965 to 1970	123
37.	Forecasts of Quarterly Average Retail Price of Beef, 1965 to 1970	124
38.	Forecasts of Quarterly Average Retail Pork Price, 1965 to 1970	125
39.	Forecasts of the Wholesale Price of Choice Grade Beef Carcasses (LCL) at New York, Chicago, Los Angeles, San Francisco, and Seattle, June 1964 to June 1970	127
40.	Forecasts of the Utility Cow Beef Price at New York City, June 1964 to June 1970	128
41.	Forecasts of the Weighted Average Price of Choice Steers at Twenty Markets, 1964 to 1970	129
42.	Forecasts of the Price of Good and Choice 500-800 lb. Feeder Steers at Omaha, 1964 to 1970	130
43.	Forecasts of the Weighted Average of Wholesale Prices of Individual Pork Products at Chicago, 1964 to 1970	131
44.	Forecasts of the Weighted Average Price of Barrows and Gilts at Eight Markets, 1964 to 1970	132
45.	Forecasts of Annual Average Retail Beef Price, 1964 to 1970	134
46.	Forecasts of Annual Average Price of Beef Cattle Received by Farmers, 1964 to 1970	135
47.	Forecasts of Annual Average Price of Other Meat at Retail, 1964 to 1970	136
48.	Forecasts of Annual Average Price of Other Meat by Farmers, 1964 to 1970	137
49.	Price Forecasts for Choice 900-1100 lb. Steers at Chicago, 1965 to 1970	140

50.	Price Forecasts for Choice 900-1100 lb. Steers at Omaha, 1965 to 1970	141
51.	Forecasts of Weighted Average Deflated Price of all Grades of Slaughter Steers at Three Markets, 1965 to 1970	142
52.	Joint Frequency of Occurrence of U_1 and U_2	149
53.	Number of Coincident Rankings of Forecasting Devices (of 22 Possible)	151
54.	Comparison of Econometric Model Forecasts with Trigonometric Model Forecasts	158

APPENDIX TABLES

A1.	Exogenous Variables used in the Hayenga and Hacklander Model	188
A2.	Hayenga and Hacklander Model: Actual and Estimated Endogenous Variables	189
A3.	Hayenga and Hacklander Model: Forecasting Performance	1 90
A4.	Exogenous Variables Used in the Myers Models	1 91
A5.	Myers Structural Model: Actual and Estimated Endogenous Variables (1)	192
A6.	Myers Structural Model: Actual and Estimated Endogenous Variables (2)	1 93
A7.	Myers Structural Model: Forecasting Performance	1 94
A8.	Myers Stage I Equations: Actual and Estimated Endogenous Variables (1)	195
A9.	Myers Stage I Equations: Actual and Estimated Endogenous Variables (2)	196
A10.	Myers Stage I Equations: Forecasting Performance	197
A11.	Exogenous Variables Used in the Trierweiler and Hassler Model	198
A12.	Trierweiler and Hassler Model: Actual and Estimated Endogenous Variables	199
A13.	Trierweiler and Hassler Model: Forecasting Performance	200
A14.	Crom Simulation Model: Actual and Estimated Endogenous Variables (1)	201
A15.	Crom Simulation Model: Actual and Estimated Endogenous Variables (2)	202
A16.	Crom Simulation Model: Actual and Estimated Endogenous Variables (3)	203

A17.	Crom Simulation Model: Forecasting Performance (1)	204
A18.	Crom Simulation Model: Forecasting Performance (2)	205
A19.	Crom Simulation Model: Forecasting Performance (3)	206
A20.	Exogenous Variables Used in the Unger Model	207
A21.	Analysis 1 Unger OLS	208
A22.	Analysis 2 Unger 2SLS	209
A23.	Analysis 3 Unger UNK	210
A24.	Analysis 4 Unger 3SLS	211
A25.	Analysis 5 Unger I3SLS	212
A26.	Analysis 6 Unger LISE	213
В1.	Structural Equations for the Hayenga-Hacklander Model	214
в2.	Structural Econometric Model From Myers, et. al.	215
в3.	Estimated Coefficients for Myers Stage One Equations	217
В4.	Structural Equations from Trierweiler-Hassler Model	218
В5.	Estimated Coefficients of the Unger Model (Ordinary Least Squares)	220
В6.	Estimated Coefficients of the Unger Model (Two Stage Least Squares)	221
В7.	Estimated Coefficients of the Unger Model (Unbiased K - Class)	222
в8.	Estimated Coefficients of the Unger Model (Three Stage Least Squares)	223
В9.	Estimated Coefficients of the Unger Model (Iterated Three Stage Least Squares)	224
B10.	Estimated Coefficients of the Unger Model (Limited Information Single Equation)	225
C1.	Reduced Form Equations Corresponding to Myers Structural Model	226

LIST OF FIGURES

1.	Quarterly Model of Beef and Pork Sectors of the	
	Livestock - Meat Economy: Richard Crom	50
2.	Characterization of Decision Rules Within the	
	Futures Market	95

CHAPTER I

INTRODUCTION

Setting .

Most departments of agricultural economics conduct both research and extension efforts involving major segments of the agricultural economy of the respective states. The extension efforts include the public provision of price information and outlook (forecasts) in addition to pertinent information regarding industry structure and economic performance in order to assist the industry adapt to its changing environment. The research effort may be conducted by the same individuals as are involved in the extension, but often there is a division of labor. In particular, there is almost always a separation of responsibility between those who are conducting methodologically oriented research and those who are doing the practical work involved in forecasting.

There is little question that methodological studies can be useful to those involved in forecasting. Perhaps, a more significant question is whether they are, in fact, useful to those who forecast. The question which is asked in this thesis is "How useful are some selected recent published studies of the fed beef cattle sector in providing a basis for generating price forecasts?" The answer provided by this research should assist forecasting personnel to evaluate the basis for their work.

In this research, the focus is on the "scientific," or verifiable aspects of forecasting, rather than the "art" of forecasting, which in part consists of projecting (or obtaining projections of) the exogenous variables of the system, determining which of the variable factors outside the system should have an impact on the system (violations of ceteris paribus), and appropriately adjusting the original forecasts to reflect these changes. Specifically, the forecasts studied in this research come from explicit models and identified data sources. In the cases where it would be necessary to project concurrent values of the exogenous variables, an assumption of perfect foresight (made possible by the expect nature of this analysis) will be utilized.

Objectives

The preceding discussion has been intended as a brief view of the philosophical orientation of this research. The specific objectives to be accomplished are:

1. To develop a measure of forecasting performance derived from the actual losses of foregone profit or reduced welfare resulting from the error of forecast. This measure will then be

A forecast is scientific if it generates "verifiable predictions by means of a method which is also verifiable." - Henri Theil (71, p. 10). See also Mincer and Zarnowitz (55, p. 3).

It should be noted that this assumption will tend to put the forecasts based upon structural econometric models in somewhat more of a favorable light than they would be if these variables had to be forecast.

related to the more conventional measures of forecasting performance to clarify the relationship between the two types of measures.

2. To determine the forecasting effectiveness of several models with endogenous beef prices which differ from each other by degree of complexity, length of run, and by means of statistical estimation. Their performance in explaining beef prices will be measured using the measures developed and examined under objective one. On the basis of these empirical results, potentially fruitful areas of further research on forecasting theory and practice will be suggested.

Literature Review and Research Approach

Since there are two separate foci of this thesis - one involving the purely theoretical aspects of forecast evaluation and the other specific to forecasting models of the beef industry - there necessarily will be two corresponding sections to this literature review.

The central figure in the literature of forecast evaluation is Henri Theil. His research evaluating the Dutch and Scandinavian forecasts culminated in at least three books (71, 72, 73) on the subject, as well as numerous articles, of which (74) is among the earliest. The thrust of his work on forecast evaluation revolved around the assumption of a quadratic loss (or welfare) function. Consequently, his two inequality measures are transformations of the mean squared forecasting error. His work firmed up the concept of the "failure of a forecast" as the

performance of a forecast relative to one of no change in the variable under consideration.

The approach taken in the theoretical section of this thesis was to perform Theil's analysis starting from assumptions several steps earlier in the process. Namely, an industry is considered which is governed by homogeneous production functions (alternatively, by honogenous cost functions) for which output price is being forecast. The analysis then determines the form of the loss function which is appropriate to represent the foregone profits which resulted from the forecasting errors. Since the derivation of the cost-related loss function consists of purely mathematical analysis, care must be taken to assure that all the implications and interpretations present in such a structure will be obtained.

Zarnowitz (86) and Stekler (66) both evaluated a number of macroeconomic forecasts in their research. Their performance criteria were mean squared error, average absolute error and Theil's Inequality Coefficients. The modus operandi in each case was to compare a set of forecasts (or forecasting models) with each other and with several extrapolative devices. Generally the conclusion was that the econometric models and other formal forecasts performed better than the naive extrapolation models.

With the methodology of these studies as a pattern, I set out to ascertain the performance of econometric models of the beef subsector in predicting beef prices. This objective guided my search of the literature regarding the beef industry. A study

By restricting the search to published models, many of the models actually used in the industry to derive forecast upon which decisions are made were excluded from consideration.

was determined to be relevant if it 1) was based on an econometric model which 2) contained beef prices among its endogenous variables, and 3) was estimated over a sample period sufficiently recent to render it potentially usable for forecasting in the late 1960's.

The articles examined were categorized as monthly, quarterly, or annual depending upon the type of data used. In addition, it was noted whether the futures market was given explicit notice.

The monthly analyses that were examined included two studies by Hayenga and Hacklander (29, 30), one by Myers et. al. (57), two by Trierweiler and Hassler (79, 80), and one by Bullock and Logan (6). All models were attempts to analyze the price structure in the livestock subsector and both the Myers (57) and one of the Hayenga-Hacklander (30) studies included exercises indicating a use of the models for forecasting. The Bullock-Logan analysis made use of a forecasting equation for slaughter steers in California to guide feedlot marketing decisions. For this thesis, it was decided to limit the analysis to only three of the monthly studies (29, 57, 80).

The only representations of the livestock subsector of an intermediate length of run were the work of Richard Crom (9, 10)

The reasons for exclusion of the other models are these. The results presented in (79) and (80) are identical and the analysis of (79) would be redundant. Bullock's study (6) had an orientation toward something other than building an econometric model to explain beef prices -- further there was the problem posed in attempting to relate his California price (El Centro) to the midwestern (Corn Belt) prices more typically analyzed.

The other Hayenga-Hacklander study (30) was excluded because the authors presented several alternative forms for a number of the relationships, rather than postulating a single model. A case could be made for inclusion based on the fact that it follows closely the format its senior author uses in his own forecasting work, and because it allows for a number of lengths of forecasts to be generated from a single month's data.

and by Crom and Maki (11). The first two studies used quarterly data, while the last used semiannual and annual data. It was decided to analyze only (9), because it appeared to be an update of (11) and because (10) does not deal at all with price variables as endogenous factors - only placements on feed, average weights per head, and numbers of animals marketed.

A number of annual models of the livestock sector have been developed. The classical study of the sector is that of Hildreth and Jarrett (36). Since it was completed in 1955 it is dated, but Richard Feltner (19) has done some work to update the model. Two more recent articles which have gained wide professional recognition in this area are by Egbert and Reutlinger (16) and by Langemeier and Thompson (48). Unger (81) used a model of the livestock sector to compare alternative simultaneous equations estimators. Uvacek (83) estimated a demand equation for beef, but did not consider supply factors. Walters (84) used beef prices as exogenous variables in the determination of cattle inventories, but had no demand representation to set the prices.

The only annual model selected for analysis in this study was that of Unger, for a number of reasons. It is similar in form to and of more recent vintage than the model of Feltner (19).

More significantly, since it presents estimates of the same econometric model obtained by six different estimation techniques, it is a natural experiment to determine the effect of estimation technique on forecasting performance. The Egbert-Reutlinger and Langemeier-Thompson models were excluded because of nonlinear identities and equations which they contained, preventing the

derivation of an explicit reduced form on which to base the forecasts.

The empirical analysis of the models involved a number of steps in the process: The first of these is to verify that the coefficients of the structural model are (or appear to be) free of any obvious errors of transcription or typography. Then, the data series for which the model was estimated is extended through the test period. At this point the model and data are combined with an appropriate computer program to calculate reduced form estimates and evaluate them with the performance measures.

The models with which the econometric models are compared consist of the extrapolation of past time trends as approximated by both Taylor series and Fourier series, weighted averages of previous observations of the price variables (where the weights correspond to assumptions that certain order differences of the price variables are randomly distributed about zero), and, in the case of the monthly models, they are compared with forecasts implied by currently prevailing levels of futures market prices.

The comparison of these models against the forecasts implied by cattle futures prices is, I think, unique to this analysis. The literature which has developed around the beef futures market includes only one study of the forecasting effectiveness of the

¹ For each type of series, there is necessarily a finite number of terms in the approximation. The Taylor series approximation consists of a linear combination of the first n powers of the time variable. The Fourier series approximation to a general periodic function (with period 1/f, or frequency f) consists of an intercept, the weighted sum of sine and cosine functions of time - each with frequency f, and the weighted sum of similar sine and cosine functions of time - with frequencies k'f, for integer values of k.

market - that by Purcell (61). In his study there was no standard against which the future prices were judged, only the inference that the market was an ineffective forecasting device because the range of errors was greater than zero.

The remainder of the thesis consists of four chapters. A theoretical chapter develops a measure of forecasting performance which is related to the cost structure of the firm (or supply elasticity in the industry) and relates this measure to other, more conventional, measures of forecasting performance. The next chapter presents a descriptive discussion of the models (econometric, trend, futures market, and price difference) which were used in the analysis. The succeeding chapter presents the evaluation of these forecasting models: examining the stability of the econometric models, measuring the performance of all the models in generating one-step-ahead forecast, and examining the relative ability of the price difference models and the futures market price in forecasting prices several (as many as eight) months in advance. Finally the conclusions and implications are presented together with recommendations for fruitful extensions of the theory of forecasting and in the empirical analysis of the beef cattle sector of the agricultural economy of the U.S.

CHAPTER II

SOME THEORETICAL CONSIDERATIONS IN FORECAST EVALUATION

This chapter consists of four sections. The first discusses forecasting as a problem of statistical decision theory. The second carries out the decision analysis for a class of firms which has been the focus of considerable economic theorizing - those with homogeneous production functions - and then aggregates to obtain an industry wide measure of loss. The resulting cost derived loss function is analyzed to determine its relationship to some of the more common measures of forecasting performance. Finally, all the measures of forecasting performance to be used in this thesis are presented and briefly discussed.

Forecasting as a Decision Problem

A person who makes a forecast is making a statement about an event which is yet to be observed. The forecaster generally suffers embarrassment if the forecasted value and the realized value are too divergent, and in addition, the firms relying upon the forecaster will incur losses which reflect the divergence of the ex ante and ex post production decisions.

In the abstract, there is a set of values one of which characterizes the market during the forecast period. Just which one will characterize the market is not known with certainty. The forecaster

must take an action - make a statement as to which of the values he thinks will prevail in the forecast period. Based on the action he takes and the state of nature which prevails a loss will be incurred both by him (embarrassment) and by the firms relying on his forecasts (less than maximal profits). The behavioral assumption implicit in this analysis is that the forecaster behaves in such a way as to try to minimize these losses. As thus posed, forecasting is a standard problem of statistical decision theory.

Following is a review of the vocabulary of statistical decision theory. 1

The decision setting is characterized by the Cartesian product of the state space and the action space. The state space is a set whose elements describe the plausible states of nature or characterize the phenomenon under analysis. The action space consists of those elements which describe the actions which the decision maker can take. In the case where the action space consists of only two elements the analysis is formally equivalent to hypothesis testing. When there are an infinite number of elements in the action space, the analysis parallels estimation theory.

There corresponds to each decision setting a loss function which measures the consequences of the decision. Formally, the loss function is a function, L(r,p), which is defined on the product of the action and state spaces measuring the loss incurred when action p is taken and the state of nature is characterized by r.

Occasionally, analyses are made in terms of regret, rather than loss,

¹ This glossary draws quite heavily upon Lindgren (50).

where regret is defined to be the difference between the loss for a given state/action pair and the minimum loss for that state:

R(r,p) = L(r,p) - min L(r,p). Thus, for each state there is an p action which results in zero regret, and all other values of the regret function are nonnegative. In the analysis presented in this discussion the loss functions will in fact be regret functions.

When it has been decided that additional information is needed in the decision process, the set whose elements are these bits of information is called the sample space. The probability of occurrence of each point in the sample space depends upon the state of nature prevailing so that the observation of a particular event will provide additional information on the state of nature. Following through in this approach, a sample observation should lead to a prescribed action which would be appropriate to the information provided. This mapping from the sample space to the action space is called a decision rule - prescribing an action p which corresponds to each conceivable observation in the sample space.

Decision rules may be arrived at in a number of ways, not all of which require explicit use of the sample information. For example, the same action might be chosen in all situations, such as always estimating a parameter to be equal to zero (or some other constant), The minimax principle prescribes a decision rule which varies from situation to situation but need not depend upon the observed sample values. It states that, whatever the data, choose that action for which the maximum expected loss over all states of nature is smallest.

¹ See, for example (3, p. 129) or (37, p. 7).

When an action is determined independently of sample information, the rule for determining such action is generally called a strategy instead of a decision rule. Strategies may be mixed (determined by a probability distribution on the action space) or pure (determined by a degenerate probability distribution with all its mass concentrated at a single point in the action space).

The Bayes decision rule states that given a probability distribution on the states of nature (such distribution may be either an a priori or an a posteriori distribution), select that action which minimizes the expected loss (or regret). Depending on whether the distribution is prior or posterior, this decision rule may or may not be independent of the sample observations. 1

In the analysis in the remainder of this essay the Bayesian Decision rules will be the primary focus of attention.

Returning now to the situation facing the forecaster, the state space for his situation is the set of possible realizations of his forecasts. The action space is the set of plausible forecast values. The loss suffered as a result of forecast inaccuracy is taken to be the marginal value of perfect information - the difference between maximum profit under perfect information and the profit realized from plans based on the forecasts. This assumption abstracts from any personal embarrassment on the part of the forecaster - unless this were assumed to be proportional to the losses incurred by his client. Since the forecaster's credibility is dependent (inversely)

This dependence may be shown in the relation between the prior and posterior distribution. If $g(\theta)$ is the prior distribution on the state space and $f(z|\theta)$ is the conditional distribution of the sample observation z, given the state of nature is θ , then the posterior distribution is $h(\theta|z) = f(z|\theta) g(\theta)/f(z)$ where $f(z) = \int f(z|\theta) g(\theta) d\theta$.

upon the losses incurred, the behavioral assumption of minimizing expected loss would seem justified.

As a case study, a firm with a homogeneous production function will be analyzed to determine an appropriate loss function and type of forecast which minimizes the expected loss based on this function.

Forecasting for a Firm

In this section a loss function which pertains to a perfectly competitive, single product firm with a homogeneous production function will be derived. This analysis is based on the assumption that only the output price is being forecast, and that input prices are predetermined (not subject to forecast nor influenced by the forecast).

In this study the loss resulting from imperfect foresight (forecasts) which is incurred by a firm is defined to be the difference between the profit realized assuming complete belief in the forecast and the maximum profit which can be realized under the price which prevails in the forecast period. The latter is obviously larger, and the order of subtraction is taken so that the loss is always positive or zero.

A homogeneous production function of degree h has a resulting total variable cost function which is also homogeneous, 1 but of

Henderson and Quandt (33) presents a proof based on knowing the optimal amounts of inputs which will produce a single unit of output. An alternative proof which derives these in the process is as follows: Let $q = f(x_1,x_2) = x_1^h f(1,x_2/x_1) = x_2^h f(x_1/x_2,1)$ be the homogeneous production function, and let $c(q) = p_1x_1 + p_2x_2 - \lambda(f(x_1,x_2) - q)$ be

degree 1/h. That is, the total variable cost function takes the form $c = k q^{1/h}$, where q is the output and the constant of proportionality, k, depends upon the input prices and the parameters of the production function, particularly as they affect input substitution. One observes a rising marginal cost curve whenever the production homogeneity, h, is less than one (decreasing returns to size), which is a necessary condition for determination of the optimum level of output by the firm in a competitive market.

Equating marginal cost to product price, the profit maximizing level of output for the firm with total variable cost function $c = k \ q^{1/h} \quad \text{is} \quad q = \left\{\frac{h \ p}{k}\right\}^{h/(1-h)}, \text{ where } p \quad \text{is the output price}$ upon which the firm bases is decision. This relationship is, in fact, the short run supply curve for the firm. Note that h/(1-h)

$$c = (\frac{p_1}{(f(1,r^*))^{1/h}} + \frac{p_2}{(f(1/r^*,1))^{1/h}}) q^{1/h}$$
 or $c = k q^{1/h}$.

the Lagrangian cost function, representing the total variable costs. The partial derivatives of the TVC function with respect to the input levels and the Lagrangian multiplier are:

 $[\]frac{\partial c}{\partial x_1} = p_1 - \lambda x_2^{h-1} f_1(x_1/x_2, 1) = 0, \quad \frac{\partial c}{\partial x_2} = p_2 - \lambda x_1^{h-1} f_2(1, x_2/x_1) = 0, \text{ and}$ $\frac{\partial c}{\partial \lambda} = q - f(x_1, x_2) = 0. \quad \text{Taking the ratio of the first two partials, we}$ $\text{obtain } \frac{x_1}{x_2} = (\frac{p_1}{p_2} \frac{f_2(1, x_2/x_1)}{f_1(x_1/x_2, 1)})^{\frac{1}{h-1}}, \text{ which is valid whenever } h \neq 1 \text{ and}$ $f_1 \quad \text{is bounded away from zero. These conditions, together with continuity of the partials assume a solution to the equation, by Brower's Fixed Point Theorem. Denote the fixed point <math>(x_2/x_1)^*$ by r^* and return to the alternative forms of the production function. These imply that the input levels employed are: $x_1 = q^{1/h}/(f(1,r^*))^{1/h}$ and $x_2 = q^{1/h}/(f(1/r^*,1))^{1/h}$. Substituting this onto the cost equation, we obtain:

is the price elasticity of supply of this commodity from this firm. In this and further discussions, n will be used to denote this elasticity, $\frac{1}{n} = h/(1-h)$.

If the firm perfectly foresees the output price which is realized, r, the maximum profit 2 realized will be equal to $(n/k)^n(1+n)^{-1-n}$ r $^{1+n}$. Assume now that there is a divergence of the realized price from the forecasted price, specifically let r represent the realized price and p represent the forecasted (predicted) price. The firm will determine its output by equating its marginal cost to p, rather than r, but its actual profit will be determined by the realized price r, in conjunction with the output which was determined by the forecasted price p. This realized profit is $[(1+n)rp^n - np^{1+n}](n/k)^n/(1+n)^{1+n}$. Since the maximum profit under perfect foresight has already been given, the loss, as defined, is

$$L(r,p) = [r^{1+n} - (1+n) r p^n + n p^{1+n}](n/k)^n/(1+n)^{1+n}$$
.

Notice that this loss function is quadratic if the price elasticity of supply, n, is equal to one (which occurs when the homogeneity of the production function is one-half), viz. $(r-p)^2/4k$.

This transformation maps the [0,1) interval for h into the nonnegative reals for n. Some of the alternative statements of the defining relationship are h = n/(n+1), 1 + n = 1/(1-h), or 1 - h = 1/(1+n).

The sense in which "profit" is used herein is as the return which accrues to the fixed factors of production. Accounting for fixed charges does not affect the loss function which is derived.

This analysis of the loss accruing to a firm can be extended to measure the cost to an industry which used the forecasts. As currently construed, this is dependent upon the assumption of an infinitely elastic demand.

If the m firms of the industry have identical short run scale parameters (i.e. homogeneities), with the possibility allowed that the cost coefficients, k_i : i=1...m, may differ from firm to firm due to for example, differing - but known - input prices, possibly reflecting marketing diseconomies, or differing rates of input substitution, the potential income lost by the industry resulting from inaccurate forecasts is

$$\Delta Y = [r^{1+n} - (1+n) r p^n + n p^{1+n}] \sum_{i=1}^{m} (n/k_i)^n/(1+n)^{1+n}$$
.

Notice that the basic loss function in this expression differs from that of the individual firm by only a multiplicative constant.

If social welfare were represented as the sum (or for that matter, a convex linear combination) of the individuals utility functions and those functions were reasonably linear over the range of variation considered important, the change in social welfare would take on the same appearance as AY except that the numerator in the sum would also include the product of the individual's weight in the social welfare function and the marginal utility of income together with n.

The obvious economic criterion states that the forecasts should be improved only to the extent where the welfare gain equals

I am having some difficulty in wrestling with the dynamics of a "consumer surplus" type of framework for a demand curve with a finite price elasticity.

the social marginal costs of improving them. Thus, the economically optimal forecast need not be the statistically best forecast. The relations of statistical measures of accuracy to this welfare criterion will be examined below.

Analysis of the Cost Derived Loss Function

Now that the forecaster realizes that the loss from his forecasting errors is proportional to r^{1+n} - (1+n)r p^n + n p^{1+n} , what would he do to take advantage of this in his forecasts? If he followed a Bayesian strategy, he would minimize the expected loss accruing under his forecasts. Taking the derivative of the expected loss expression with respect to the forecast p, he obtains -n $(1+n)E(r)p^{n-1}$ + n $(1+n)p^n$ which will be zero only in the cases when p is zero or p is equal to E(r), of which the former makes no sense and the latter is the same forecast he would have obtained had he used a quadratic loss function.

What has the forecaster gained by participating in this exercise? In terms of the forecasts he derives, nothing. But in terms of evaluating alternative forecasts - possibly based on different maintained hypotheses - quite a bit, for he now has a measure

The second derivative of the expected loss function is $n^2(1+n)p^{n-1} - (n+1)n(n-1)E(r)p^{n-2}$. When p=0 this is zero, indicating a point of inflection of the function, and when p=E(r) the second derivative is positive (assuming that E(r) is positive and the elasticity is either positive or less than -1.0) which implies a local minimum of the loss function.

Since a quadratic loss function is the special case of this loss function when n = 1, and since nothing in the optimization process relied on n in a crucial manner, we see that the Bayes decision (forecast) is the same with a quadratic loss as with the more general cost derived loss function.

of the actual loss resulting from the different forecasts to use as a criterion for choice between the different forecasting models.

The minimum value of the expected loss in the case of the quadratic loss function is proportional to ${\rm E(r}^2)$ - ${\rm (Er)}^2$, which is the variance of the posterior distribution of r. For the cost derived loss function this minimum is proportional to ${\rm E(r}^{1+n})$ - ${\rm (Er)}^{1+n}$, which might be called a quasi-variance.

A factorization of the cost derived loss function is informative. This is only possible in the case where n is a rational number, which implies that the homogeneity must also be a rational number. If we represent n as a/b, implying that the homogeneity is a/(a+b), we can obtain these relatively prime factors of the loss function:

$$L(r,p) = (r^{1/b} - p^{1/b})^{2} [r^{(1+b-2)/b} + 2r^{(a+b-3)/b} p^{1/b} + ...$$

$$+ a r^{(b-1)/b} p^{(a-1)/b} + (a/b) ((b-1)r^{(b-2)/b} p^{(a/b)} + (b-2)r^{(b-3)/b} p^{(a+1)/b} + ... + p^{(a+b-2)/b})].$$

Two special cases perhaps provide more insight than this most general case: when n=i is an integer (the production homogeneity would be h=i/(1+i)), and when n=1/i is the reciprocal of an integer (h=1/(1+i)). When the elasticity of supply is an integer

Note that this is not generally the same as the 1+n central moment of the posterior distribution of r. For it to be that, the moment of the distribution would have to satisfy $(Er)^n = \sum_{j=0}^n (-1)^j (Er)^j (Er^{n-j}) \binom{n+1}{j+1}$, in the case where n is an integer. As we already know, this restriction is satisfied for all distributions if n=1.

the loss function factors into

$$L(r,p) = (r - p)^{2}(r^{i-1} + 2 r^{i-2} p^{1} + ... + i p^{i-1}),$$

and when the supply elasticity is the reciprocal of an integer, the loss function factors into

$$L(r,p) = (r^{1/i} - p^{1/i})^2 (i r^{(i-1)/i} + (i-1) r^{(i-2)/i} p^{1/i} + ... + p^{(i-1)/i}).$$

In the case where the supply elasticity is an integer (greater) than one), for a given magnitude of forecasting error, the loss is greater if the forecast exceeds the realized price. This means that an overestimate would be worse than an underestimate. When the reciprocal of the elasticity is an integer, the converse is true (the loss is greater when the forecast is less than the realized price). In either case, one should note that mere knowledge of the forecasting error alone is not sufficient to evaluate the forecasting loss.

The practical implication of this is that when ranking forecasts on the basis of the effect their errors have on firm profits, a squared error criterion would probably provide a correct ranking of the forecasts, although it is not sufficient to quantitatively estimate the actual effect of these errors on the firms.

Measures of Forecast Performance

This section will analyze the effectiveness of several of the more widely used measures of forecasting accuracy in achieving a ranking of forecasts consistent with the welfare loss associated with the forecasting device.

As has been shown above, the welfare loss of each forecasting error is proportional to r^{1+n} - (1+n) r p^n + n p^{1+n} where n is the short run supply elasticity and the forecast is p when the realization is r. This suggests that forecasting performance should be measured by $\frac{1}{N}\sum_{i=1}^{N} (r_i^{1+n} - (1+n) r_i p_i^n + n p_i^{1+n})$, where p_i and r_i are the i-th forecast and realization, respectively, of the price variable under consideration, and N is the number of observations in the evaluation period. The interpretation of this measure would be the average welfare loss, and the ranking of forecasting methods so derived would be considered to be consistent with social welfare.

A number of widely used measures of forecasting performance can be shown to be simply transformations of a quadratic loss criterion or are related thereto. Most obviously so are Theil's inequality coefficients and the mean squared error, but it can be shown that the forecasting bias, forecast correlation (between forecast and realization), and the forecast slope (of the descriptive regression of forecast on realization) all are identifiable components of the mean squared error of forecasting.

The Theil inequality measures are defined as follows:

$$U_{1} = \frac{\sqrt{\sum(\Delta r_{i} - \Delta p_{i})^{2}}}{\sqrt{\sum(\Delta r_{i})^{2} + \sqrt{\sum(\Delta p_{i})^{2}}}} \quad \text{and} \quad U_{2} = \frac{\sqrt{\sum(\Delta r_{i} - \Delta p_{i})^{2}}}{\sqrt{\sum(\Delta r_{i})^{2}}}.$$

Consistent with our prior notation r represents the realized price and p the forecasted price level. When we define the change used as the basis for the inequality coefficients as the change from the previous realized price, the numerator in each case becomes $\sqrt{\Sigma(r_i-p_i)^2}$ since the r_{i-1} terms subtract out.

It is well known that U_1 lies in the closed interval zero to one (11). The proof is based on the Schwartz Inequality, which is the basis for proof that the correlation coefficient is in the interval $[0,1]^{.1}$. The lower bound is attained when the forecasts are perfect, and the upper bound either when all forecasts indicate no change or when there exists a negative constant of proportionality between the forecast and the realization (indicating perfect negative correlation). What seems to be less well known is the threshold, below which all values of U indicate positive correlation between forecasts and realizations and above which negative correlations are indicated. This is given by $U_1 = \sqrt{1+w^2}/(1+w)$, where w^2 is the ratio of the sum of squared actual changes to the sum of squared predicted changes. The minimum value of this expression is $\sqrt{2}/2$, when w = 1, and the expression approaches one as w becomes large.

See for example (6, p. 107).

Another property of this expression is that f(1/w) = f(w), where $f(x) = \sqrt{1 + w^2/(1 + w)}$. The implication of this finding is that any forecasting scheme which resulted in U_1 being greater than 0.7 would be suspect, while those resulting in a smaller U_1 coefficient can be said to be at least positively correlated with the realized price. $\frac{2}{1 + w^2}$

The \mathbf{U}_1 coefficient is related to the mean squared error as follows:

$$U_1 = \sqrt{MSE} / (\sqrt{\Sigma(\Delta r_i)^2/N} + \sqrt{\Sigma(\Delta p_i)^2/N})$$
.

As can be seen from its definition \mathbf{U}_1 depends upon the numerical size of both the forecasts and the realized prices, as well as the mean squared error. Thus it is possible for two forecasting models for the same price series to have the same \mathbf{U}_1 values and different mean squared errors.

This rule of thumb is somewhat contingent on the (believable) assumption that the mean squared successive differences of the forecasts and realizations are approximately of the same magnitude. For purposes of an approximate probability statement, Theil (72, p. 32) has derived an upper bound assuming independent (r_i, p_i) pairs on the variance of U, which is $1/n Y^2 (1-Y^2)^2$, where Y is the same function of the population moments as U_1 , is of sample moments and n is the number of forecasts which are evaluated. When $Y^2 = 1/2$ (when

To overcome this latter objection to U_1 and to arrive at a measure which is more closely related to what he called the failure of a forecast, 1 Theil (74) developed the U_2 inequality measure.

This is represented by the formula $U_2 = \frac{\sqrt{\sum(\Delta r_i - \Delta p_i)^2}}{\sqrt{\sum(\Delta r_i)^2}}$. Its

square is the ratio of the mean square forecasting error to the mean square successive difference of actual prices.

 $\rm U_2$ can take on all positive values and is equal to unity if the forecast performs the same as a no change extrapolation. Obviously, smaller values of $\rm U_2$ are preferred to larger ones. Rankings by $\rm U_2$ for a given forecasted series are expected to be consistent with the rankings by mean squared error. This is to say, that the forecast which minimizes mean squared forecasting error will minimize $\rm U_2$ as well.

Both of the inequality coefficients were heavily dependent upon the quadratic loss criterion in their development. Theil's welfare analysis of prediction made extensive use of the assumption of a quadratic welfare function (73) mostly because of its tractability and at least partly as an approximation to the results obtained by more general functions. As we say above, only the second inequality measure will always rank forecasts of a given variable consistently with mean squared error.

 $[\]rho(r,p)=0$) this variance would be 1/8n and a 2 σ confidence bound would be $1/\sqrt{2n}$. Such probabilistic approach is not incorporated into the rule of thumb stated above.

¹ The failure of the forecast is defined as the ratio of the difference between the welfare (profit) accruing under the realization and that under the forecast to the difference of realized welfare and the welfare which accrues under a no-change forecast. See (11) or (12).

The mean squared error, which has formed the bench mark of our previous discussion, is defined as $E(r-p)^2$, or as a simple statistic as $MSE = \frac{1}{n} \sum (r_i - p_i)^2$. It represents the average squared error of the forecasts and can be shown equal to the squared bias plus the variance (loosely defined) of the forecast. If the "descriptive regression" $r = b_0 + b_1 p + U$ is formed, the mean squared error can be expressed as

$$\text{MSE} = (\bar{r} - \bar{p})^2 + (1 - b_1)^2 \sigma_p^2 + \sigma_U^2 = (\bar{r} - \bar{p})^2 + (1 - b_1)^2 \sigma_p^2 + (1 - \rho_{pr}^2) \sigma_r^2.$$

This representation breaks the mean squared error into three 2 separate components: due to the forecast bias, the forecast slope, and the forecast correlation. The smaller the forecast bias, the smaller the mean squared error is expected to be. Similarly, as the slope of the descriptive regression or the correlation of that regression approaches unity, the same effect is observed. Thus there are three measures of forecast accuracy which can relate to the mean squared error measure, in the sense of a partial derivative, but whose ranking of different forecasting schemes need not coincide with the ranking by the mean squared error criterion. In addition to these, there are two inequality coefficients both of whose motivation was in the quadratic loss criterion (the second of which

¹ See (55) or (86).

This partition expands upon the information provided by the usual squared bias-variance partition, by setmenting the variance component into subcomponents representing variation along and about a "regression" equation.

Five measures, if the variances of forecasts and realizations are counted.

ranks different forecasting schemes identically with mean squared error).

In addition to the foregoing measures of forecasting performance which were derived from or partitions of a quadratic loss function (which is a special case of the cost derived loss function), there are a number of other commonly used measures of forecasting performance. The motivations of these other measures generally lay in considerations other than the explicit cost related loss. Those to be discussed (and later applied) are the class of absolute moment measures, the average relative error (which is a "normalized" variation of the simplest member of the class of absolute moment measures), and the number of turning point errors.

¹The m-th root of the typical member of this class is a discrete analog to the norm of the L^p space where p = m. See Royden (64).

The measures within this class differ in the relative weights given to errors. The amount of weight ascribed to "outlying points" increases as m increases. For example, an error of two units would be weighted as two, if m were one (the average absolute error); four, if m were two (the mean square error); eight, if m were three (the third absolute moment); and sixteen if m were four (the fourth moment). Small errors (less than one unit) are weighted less as m increases. Again as an example, when the power parameter goes from one to four the weight ascribed to an error of 0.9 units decreases from 0.9 to 0.6561.

These measures, like all those considered earlier excepting the inequality measures, are measured in the same units as the variable being forecast. Thus to use these measures in evaluating forecasts of several variables the user would have to refer back to the original data series to determine how small a "small" forecasting error is. To achieve a dimensionless quantity, the absolute error could be transformed to obtain the relative error (by dividing by the realized value of the variable). There would be an entire class of measures thusly formed analogous to the absolute moment class of measures. The only element of this set which was used in this thesis is the average relative error, which was defined as a.r.e. = $1/N \sum_{i=1}^{N} \frac{r_i - p_i}{r_i}$.

Unless there were a substantial degree of variation in the variable whose forecasts are being studied, one would expect a considerable amount of agreement between rankings by the relative moment measures and the corresponding rankings obtained by the absolute moment measures with the same power parameters.

A turning point error occurs if a positive change in the variable is forecast and a negative change is realized, or vice versa, so that the product of the change in the realized variable and the change in the forecast is negative. The motivation is that it is oftentimes more important to foresee changes in the direction of events than to accurately forecast the movement in the same direction. A loss function which would represent this feeling would be one which is zero if the product of the change in the realization and the change in the forecast is positive or zero and equal to a positive constant if this product is negative. The turning point measured used herein is consistent with a loss function of that type and is defined as t.p. = $\sum_{i=1}^{N} g(\Delta r_i, \Delta p_i)$, where $g(x\,,y) \,=\, \begin{cases} 1 & \text{if } xy\,<\,0\\ & \text{.} & \text{As such it measures the number of in-}\\ 0 & \text{otherwise} \end{cases}$ correct predictions of change which were made during the test period. This measure is amenable to statistical analysis in the sense that one may calculate the probability that this many or fewer errors would occur in N forecasts, assuming error occurrence to be a Bernoulli process. A random prediction of change would be construed as having the probability of error equal to one-half.

Since this performance measure treats all turning point errors as being "equal", not differentiating between large errors and small ones, one is led to suspect that the rankings of different

 $^{^1}$ In the analysis of the quarterly variables in the Crom model Δp_i was defined as $p_i - r_{i-1}$. For the analysis of the annual variables in the Crom model and in all the other models Δp_i was defined as $p_i - p_{i-1}$.

See, for instance (57).

forecasting devices by this measure would not be identical with the other sets of rankings.

The explicit mathematical equations used in defining these measures of forecasting performance are summarized in Table 1. The assumed values of the supply elasticity used in the calculation of the cost derived average loss were obtained from the NC-54 study of livestock and feed grain supply response (8). The precise values used were 0.04 (the U.S. supply elasticity of pork production), 0.12 (the price elasticity of beef production in the current year), and 0.32 and 0.34 (the elasticities of beef production two and three years subsequent to the price change). It has already been mentioned that the mean square error falls into several categories - in the tabulation it will be considered as the cost derived average loss with supply elasticity equal to one.

The succeeding chapter will use these measures as the basis for evaluating the forecasts of beef prices, and to a lesser extent other meat prices.

TABLE 1 Measures of Forecasting Accuracy

Measure Range Comments

1. Cost Derived Average Loss

C.D.L. =
$$1/N \sum_{i=1}^{N} (r_i^{1+n} - (1+n)r_i p_i^n +$$

 $n p_i^{1+n}$), n was assumed to be (0.04,

0.12, 0.32, 0.34).

Non-negative

n is the elasticity of supply for the commodity whose price is being forecast.

2. Mean Squared Error

M.S.E. =
$$1/N \sum_{i=1}^{N} (r_i - p_i)^2$$

Non-negative

A c.d.1. when n = 1.0.

3. Inequality Measures

$$U_{1} = \frac{\int_{i=1}^{N} (r_{i} - p_{i})^{2}}{\int_{i=2}^{N} (r_{i} - r_{i-1})^{2} + \int_{i=2}^{N} (p_{i} - r_{i-1})^{2}}$$
 [0,1]

If $U_1 > \sqrt{2/2}$, r and p may be negatively correlated.

$$U_{2} = \frac{\sqrt{\sum_{i=1}^{N} (r_{i} - p_{i})^{2}}}{\sqrt{\sum_{i=2}^{N} (r_{i} - r_{i-1})^{2}}}$$

Non-negative

If U₂ < 1.0, the forecast is better than a nochange extrapolation.

4. Number of Missed Turning Points (Incorrect Forecasts of Change)

t.p. =
$$\sum_{i=2}^{N} g((r_i-r_{i-1}), (p_i-p_{i-1}))$$
 [0,N]

[0,N] g(x,y) = 1 if xy < 00 otherwise.

5. Average Absolute Error

a.a.e. =
$$1/N \sum_{i=1}^{N} |r_i - p_i|$$

Non-negative

TABLE 1 (Continued)

6. Average Relative Error

a.r.e. =
$$1/N \sum_{i=1}^{N} \left| \frac{r_i - p_i}{r_i} \right|$$

Non-negative

7. Third Absolute Moment

3 A.M. =
$$1/N \sum_{i=1}^{N} |r_i - p_i|^3$$

Non-negative

8. Fourth Moment

4 M. = 1/N
$$\sum_{i=1}^{N} (r_i - p_i)^4$$

Non-negative

9. Forecast Correlation

$$\rho(r,p) = \frac{\sum_{i=1}^{N} (r_i - \bar{r}) (p_i - \bar{p})}{\sqrt{\sum_{i=1}^{N} (r_i - \bar{r})^2 \sum_{i=1}^{N} (p_i - \bar{p})^2}}$$
 [-1.0, 1.0] Plus one is optimal.

10. Forecast Slope

$$b_{1} = \frac{\sum_{i=1}^{N} (r_{i} - \bar{r}) (p_{i} - \bar{p})}{\sum_{i=1}^{N} (p_{i} - \bar{p})^{2}}$$

Real

Plus one is optimal.

11. Forecast Bias

Bias =
$$1/N \sum_{i=1}^{N} (r_i - p_i)$$

Rea1

Zero is optimal.

CHAPTER III

DISCUSSION OF THE MODELS FOR BEEF PRICES

Overview of the Chapter

The type of analysis pursued in this section of the thesis might be considered to be meta-research, research on research. In any inquiry there are those propositions, or assertions, which are taken as given and which form the basis on which the conclusions of the inquiry are based. In mathematics, and logic, these are generally termed axioms. In statistical analysis, they have been termed by at least one author, (46, p. 112) the maintained hypothesis. In economic analysis, the maintained hypothesis corresponds to the model which describes the system (or market) under study.

In the execution of a research project, the first of the substantive stages consists of the determination of the maintained hypotheses in the research: This includes the structuring of the (economic) model for the system, as well as stating the assumed structure of the stochastic elements of the system (where they occur, their distributions, and any a priori information at hand regarding the parameters of the distributions, etc.).

Once the maintained hypothesis has been established, the test hypotheses (null and alternative) are formed. These may relate to the relative influence of factors within the maintained

hypothesis, or whether theoretical expectations are fulfilled, or a number of other things.

Once the test hypotheses have been established, the researcher must determine the statistics which have to be calculated and their distributions under the maintained hypothesis. From these distributions, given the acceptable levels of error probability (of both types), the critical region for each test is determined.

For models whose sole purpose is the estimation of the structure of the relationships within a given phenomenon, the above two steps are not formally carried out. However, even in these cases, hypotheses of no effect are implicitly or explicitly tested as a result of the inclusion of "t-ratios" and coefficient standard errors or variances, etc.

The sample of empirical data is then drawn and the appropriate statistics are calculated. Based on the sample value of the statistic relative to its critical value, one or another of the test hypotheses is tentatively accepted. At this time the research results are ready to be reported to the profession.

Since the solutions to the research problems are only as adequate as the maintained hypotheses, or initial premises, on which they are based, a comparison of the adequacy of the hypotheses in addressing the problems subsequent to their development should indicate the relative value of the hypotheses in later research. The methodology for testing alternative maintained (as opposed to test) hypotheses is not well developed. Indeed, the characterization of the entire set of alternative explanatory hypotheses for a

given problem set in a way which would render it amenable to the standard tools of statistical analysis is a problem in itself which could be addressed in a thesis such as this (23). In fact, this thesis has sidestepped this issue and has selected only four approaches to the forecasting of beef prices and only a small number of examples of each, taken to be representative of the set characterized by that particular approach, although no pretense of randomness is alleged concerning the selection of the examples. The approaches to be considered are econometric modelling, trend analysis, variable difference models, and the use of the price of a commodity futures contract to forecast the price of the commodity.

Econometric Models

By far the most complicated approach to forecasting is that involved in using an econometric model to generate the forecasts. If this involves beginning from scratch, considerable time, effort, and skill is required to develop satisfactory estimates of the structure under study (in this case, the beef-cattle subsector). Even when the forecasts are to be developed from existing models, the degree of technical skill required to correctly use the models is usually quite high. The information required in using this

^{1&}quot;Satisfactory" generally is interpreted as meaning that the response to the variables in the study corresponds to the prior expectations, that the individual equations closely approximate the "real world" behavior as evidenced by the empirical data, and that the numerical values of the estimated coefficients either compare favorably with prior studies, or differ for reasons which can be explained. Generally, it includes the fact that the results were obtained by methods possessing the most desirable statistical properties.

This requirement is lessened somewhat if the model chosen is recursive in form, but even to recognize this requires a degree of skill.

type of a forecasting procedure is quite great: all of the exogenous variables of the model need to be known or projected, and, if the model has to be estimated, the values of all the variables - both endogenous and exogenous - must be obtained for the sample period as well as be projected into the forecast period. Further, the data for the forecast period must be comparable to that in the sample period in terms of scope, content, and coverage, which means that data revisions need some sort of explicit recognition, lest the forecasts reflect more the change in the definitions that the actual changes in the segment of the real world which the system purports to explain. There is, however, another aspect of the information issue - more information can be provided. All endogenous variables in the system can be forecast nearly as easily as any one of them. The forecasts can explicitly reflect some of the changes in the state of the system (those aspects of "certeris paribus" which have entered the model as explicit variables) as well as possibly afford some "guesstimates" regarding the impacts of violations of other aspects of the ceteris paribus conditions.

Trend Models

Trend models may possibly be viewed in two ways: Either they represent a state of complete ignorance (or disregard) of the structure, or they constitute approximations to the time path of theoutput of a complicated system operating under reasonably stationary conditions with a stable structure. Obviously, the second hypothesis is intellectually more acceptable than the first. A dynamic system which is represented by a system of differential or difference

equations involving the endogenous variables together with the external forces represented by the exogenous variables has a solution whose time path depends upon the solution to the homogenous differential or difference equation, the time path of the exogenous variables and the initial conditions on the endogenous variables. The exact form of this path depends on the system at hand, but suffice it to say that it is exceedingly difficult to represent by the sum of simple functions. At this point, the analyst may wish to approximate the actual solution by a more tractible, mathematical representation.

Two of the numerous mathematical approximations are the Taylor series approximation and the Fourier series approximation. Taylor's theorem states that f(t) can be approximated by a finite degree polynomial whose first n-1 coefficients are the k-th order derivatives of the function evaluated at zero and divided by k factorial, but whose n-th term (the remainder) is the n-th derivative evaluated at some point x which is between zero and t divided by n factorial and multiplied by t (12, p. 82). As n becomes large the remainder tends to zero.

The Fourier series for a function is an infinite series of sine and cosine functions of increasing frequencies. If the function is periodic [i.e. f(x+p) = f(x)] then the frequencies are integer multiples of the basic frequency (1/p). If the function is not periodic, and the Fourier series is used to describe the function over a period of observations, the frequencies are integer multiples of the reciprocal of the sample period. The coefficients of the individual trigonometric functions are simply continuous

analogues of the least squares coefficients for an equation specified as $Y(t) = \overline{Y} + \sum_{k=1}^{\infty} (a_k \cos k(2\pi t/p) + b_k \sin k(2\pi t/p))$, with the sample being any integer multiple of the interval [0,p].

The functions chosen to approximate the more complicated solution to the general system are relatively simple in nature and provide explicit information regarding characteristics of the original function. The first approximation provides estimates of the derivatives of the original function, and the second is related to the original function, in that the estimated coefficients are integrals of the function (loosely defined). There are, of course, other means of approximating functions besides those chosen. In addition to the trigonometric functions, other orthogonal polynomials which may be used include Laguerre polynomials, (85) and Legendre polynomials. The generalization of the power series which accounts for isolated points of singularity is the Laurent series (1) which allows for both positive and negative powers of the independent variable.

Price Difference Models

Another, perhaps more specific way of expressing past time trends is with the use of weighted average models. If the possibility of negative weights is not excluded this set of models includes stationary variate difference models as well. The solution of the difference equation implied by the weights of the lagged variables gives the explicit form of the time dependence assumed in this type of model.

In particular, a model which assumes that the n-th difference is distributed with mean zero implies that the form of the dependence is a polynomial of degree n-l in the time variable. The superposition of seasonal variability on top of a basic difference model complicates the form, but alters little of the substance of the analysis. The forms of variate difference models which were given consideration in this analysis were pure difference models of first, second, and third degree and a first difference model which has annual variation superimposed on it.

Futures Market Price

One final forecasting device, namely the futures price, was considered to be the standard against which any forecasting device should be compared, from the standpoint of simplicity, authority, and communicability. It is simple, in that all that is necessary to obtain its forecast is to see the quotation for the contract maturing in the period being forecast. It has authority, in that the financial consequences of an error in judgement encourages somber reflection upon the conditions prevailing and likely to prevail in the market, and the fact that the participant remained in the market implies that he has passed the market's test of accuracy. The commodity futures market is communicable, in that it is fairly easy for the lay individual to understand the concept

He may or may not be using a formal model to derive his strategies, but since the market in the long run is expected to reward accuracy with profits and inaccuracy with bankruptcy, survival in the market is a minimal test of a forecaster. This perspective is consistent with the view of a futures price as an aggregate of all current price expectations.

(though not always the mechanism) of a contract for future delivery of a commodity and its associated price, and the widespread availability of most contract prices.

The price corresponding to the Chicago Mercantile Exchange contracts for live slaughter cattle was used to forecast prices of slaughter cattle. The specific slaughter prices it was used to forecast are the price for choice 900-1100 lb. steers at Chicago and Omaha, and the deflated weighted average price of all steers sold out of first hands at these two markets and at Sioux City. The for those months in which no contracts mature, the price forecast was taken to be the average of the cash price and the near term futures price. For forecasts more than one month into the future, the prices of the contracts maturing around the forecast month were averaged to generate the forecasted price for months in which no contracts matures.

The next four sections of this chapter discuss the forecasting models summarized above with greater detail. In addition to
this, the section dealing with the trend models presents the
estimated trigonometric and polynomial trend equations.

For the period of analysis, this contract called for the delivery of 40000 lbs. of choice grade live steers, with the steers in the weight range 1050-1150 lbs. estimated to dress to 61 percent and those in the range 1151-1250 lbs. estimated to yield 62 percent. Delivery was to take place in Chicago at par, or at Omaha, Nebraska, or Kansas City, Missouri, with discounts of \$0.75 and \$1.00, respectively per hundred weight. Effective with the August 1971 contracts, par delivery was to occur at Omaha, with delivery allowed at Guymon, Oklahoma, at a \$1.00 per cwt. discount, and at Chicago and Peoria, Illinois, allowed at a premium of \$0.50 per cwt. Kansas City was eliminated as a delivery point. For this and other pertinent information regarding the cattle contracts, see (7).

The Econometric Models

The analysis included econometric models based on monthly, quarterly, and annual data. Three of the models were dynamic, in the sense of containing lagged dependent variables, and the two others were not. All of the models chosen considered one or more prices of beef cattle to be endogenous to their structure and purported to explain more than simply that (those) prices. As an indication of the sizes of the models considered, the number of endogenous variables ranged from five to thirty and the number of separate series of exogenous variables ranged from five to thirteen (although the total number of actual exogenous variables was generally much larger due to the includion of trend and dummy variables in the analyses).

A brief description of the models considered is presented in Tables 2a and 2b. Table 2a indicates the relative sizes of the models, in terms of dimensions and density of the coefficient matrices, as well as the means chosen to estimate the model. Table 2b gives a rundown of the price variables which were included in each of the models.

It is noted that many econometric models are not designed for purposes of forecasting behavior in the market they represent (indeed, of the set of models under consideration in this research, only the Myers and Unger studies presented explicit exercises in forecasting with their models, although Crom did have a "validation" period outside his sample period). However, the contention in this research and concurred with by others (14) is that predictive tests are a legitimate, and often preferred, means of choosing between

Characteristics of Econometric Models under Consideration TABLE 2a

Kode1	Sample Period	Estimation Method	Number of Equations	Exogenous Data Series	Average Number of Parameters Estimated Per Equation	Average Error Degrees of Freedow Per Equation
Monthly:						
Hayenga & Hacklander	4/63 to 6/68	Two Stage Least Squares	.es	6	15.8	47.2
Myers, et. al.	1/49 to 12/66	Two Stage Least Squares (Instrumental Variables)	es) 10	13	14	202
Trierweiler & Hassler	1/57 to 12/66 g/ 1/57 to 12/67 <u>m</u> /	Ordinary Least Squares Recursive System	9	v	6.5 g/ 3.25 g/	33.5 g/ 128.75 m/
Quarterly:						
Crom	1955 to 1966	Ordinary Least Squares Recursive System	30	11	7.35 g/ 4 <u>a</u> /	27.45 g/ # 3.66 m/ #
Annue I :						
Unger	1936 - 41 and 1949 - 63	Various Methods	10	7	4.5	16.5

Footnotes:

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For equations estimated with annual data.

For equations estimated with monthly data.

For equations estimated with quarterly data.

One degree of freedom was subtracted for each restriction imposed after estimation.

TABLE 2b

		Summary of Price I	Summary of Price Variables in Econometric Models Under Consideration	Under Consideration	secondarian per Prices secondarians	***************************************	
180	Staughter Price	Molesale Price	Retall Price	Other Prices	Slaughter Price	Retall Price	Other Prices
Marin lys							
Heriender	Choice 970-1100f Stears, Chicego				No. 2-3 grade, 200-220# Barrows and @ilts, Chicago		
	Neighber everage of all greens of streens soil over of first hands in Citate hands in Citate City, defieled by MPI 37		Average retail price of choice carcass cuts of beef in U.S. urban areas, deflated by CPI 57		Eight Narias weighted Average price of barrows and glifts, detlated by Wei 57	Average retail prices of retail profit cuts and sessage in U.S. Urban areas, defiated by (Pl. 57	Average refall price of trying chicken in refull stores in L.S. Urben eress, owthere by CPI 57
Triensiler E hessier	Chol ce 900-11004 Steers, Crehe	Choice 600-700/ Cercesses, Chicago	"Retall Beef Price"		No. 1-3 grade 220-2409 butcher hogs, Omehe	"Retail Pork Price (Excluding Lard)"	
Overheritys							
8	belighted exerage price of choice greate steers at 20 merkets	beighted everage of Dolos grade carcasses at N.Y., Chicago, L.A., San Francisco, and Seetile (LCL)		Good and Choice 5:00-600f Feeder Steers, County Offility Cov Beef Price, New York	Eight market weighted Average price for Berroes and gilts	Melghted everage of tholesele prioss of individual port prod- ucts of Chicago	
Amual :							
i.	Price of Beef Ceffie of the farm level, deflated by PPFI 57		Price of Beef et retall, deflated by CP1 57		Heighted everage price of other mest at fern level, deflated by PFFI 57	Melghted everage price of other mest at retail deflated by CPI 57	Other mest includes pork, veel, lamb and mutton, chicken, turkey.

Explanation of defiators:

79: 37 • Consumer Price Index (1937-29 • 100) HP: 57 • Machesale Price Index (1937-29 • 100) FOF: 57 • Prices Paid by Fermers, including Interest, temes, wages, index (1937-39 • 100)

alternative explanatory hypotheses. If two explanatory hypotheses explain the sample period data equally well but one of them fails to predict "normal" events outside the sample, an obvious conclusion is derived relative to the two models.

The procedure used in the generation of forecasts from the econometric models consisted of 1) verifying (to the extend possible) the coefficients of the structural equations, 2) inverting the structural equations to obtain the reduced form implied by that system (this is to say, each of the endogenous variables became a function of only predetermined (exogenous and lagged endogenous) variables, rather than being jointly dependent on other contemporaneous endogenous variables), 3) re-creating and updating the data series used in original analysis to cover the test period (no mean task in view of revisions, deletions, and other editing which is done by the agencies which collect, prepare and disseminate statistical information), and finally 4) using the updated data in the reduced form equations to calculate the forecasted (or estimated) values of the endogenous variables (since most of the models made use of contemporaneous variables in explaining the system, using the actual values of these factors in the forecasting procedure should be expected to bias the analysis slightly in favor of these types of models over other types of forecasting procedures).

The monthly econometric models were the results of work at Michigan State University, Purdue University and at the University of Nebraska. One was presented as a journal article, and the other two were research bulletins published by the respective Agricultural Experiment Stations.

Hayenga-Hacklander Monthly Model

The Hayenga and Hacklander article (29) appeared in the American Journal of Agricultural Economics in November 1970. The purpose of the model was to explain the short run variations in supply and demand for both fed cattle and hogs and the variations in the storage holdings of frozen and cured pork. While only nine series of exogenous variables were used in this model, after recognizing the dummy variables which shift both slope and intercept in the model there gets to be thirty-five exogenous variables in the model as estimated. Schematically, the model is of the form A Y(t) = B Y(t-1) + C X(t) + U(t), where X(t) and Y(t) are the vectors of exogenous and endogenous variables, respectively, which are observed at time t, A, B, and C, are matrices of scalar coefficients, and U(t) is a random disturbance vector which is generated at time t. The lagged endogenous variables in the model are the result of including both levels and changes of the price and storage variables in the model.

Myers Monthly Model

The second monthly model considered in this research originated in L.H. Myers' thesis at Purdue (56) and was taken from the research bulletin (57) which was co-authored by Myers, Joseph Havlicek, Jr., and P.L. Henderson. It consists of eight behavioral equations and two identities and involves twenty-four exogenous variables, including a time trend, population, and dummy variables to alter the intercepts in six of the relations. The sample period over which this model was estimated is January 1949 to December 1966.

Although it is claimed that two stage least squares was the estimation method applied to this model, I will show that what actually occurred was more akin to an instrumental variables approach than it is to the true two stage procedure.

Although the system of behavioral equations was itself entirely linear, both the identities in the system were nonlinear. They related the per capita quantities demanded to the total quantities produced: in one case, simple division of an endogenous variable by an exogenous variable was the only process involved, but the other case involved the application of a multiplicative constant 1 (dressing yield) to the quantity produced before the division by population. Thus the system can be represented as A(p) Y = B X + U, where A(p) is a matrix whose elements are functions of population (i.e. p), rather than the constants usually assumed. Before the forecasts could be obtained from this system, via the reduced form, it was necessary to determine the inverse matrix $A^{-1}(p)$, so that we could represent the endogenous variables as functions of only the exogenous variables (including population). This was done by the process of matrix inversions by partitions: 2 First

its inverse is a matrix B which partitions conformably and whose corresponding matrices are given by

I have some doubt as to whether it was indeed a constant, or rather another variable to be reckoned with. The only mention of this constant, other than as the abstract representation in the text, is in footnote 25 on page 17 which states "average dressing yield for cattle over the period of study = .556".

The process of inversion by partitions is as follows: If a non-singular matrix A can be partitioned into

 $A = (A_{11} \quad A_{12})$, where A_{11} is nonsingular,

A(p) (as well as B and U) was rearranged so that the endogenous variables divided by population corresponded to the last two columns and the nonlinear identities were the last two equations. In this way, except for the 2 X 2 matrix elements which were containing the functions of P in the southeast corner, A(p) contained all constants. Because of this, the inverse matrix is straightforwardly obtained, with the only particular difficulty involved in the process associated with the determination of the Z submatrix (see footnote 2, p. 44).

The determination of the Z matrix is essentially a numerical process, with not much gained from purely algebraic presentation, so at this point I will retreat into the arithmetic of the particular problem: $A_{22} = \begin{pmatrix} -1.0 & P^{-1} & 0 \\ 0 & -.556 & P^{-1} \end{pmatrix}$, and based on the estimated structural coefficients

$$-A_{21}A_{11}$$
 $-A_{12}$ = (10.369339325 -1.480056935) × 10⁻³.

From this we observe that the "Z" matrix is

$$Z = (A_{22} - A_{21}A_{11} - A_{12})^{-1} = \frac{1000}{f(p^{-1})} (4.139016516 - 556 p^{-1}, 1.480056935 (2.485153142 10.369339325 - 1000p^{-1})$$

where $f(p^{-1}) = 39.24069853829 - 9904.3691807 p^{-1} + 556000 p^{-2}$

is the determinant of the matrix. With some simplification (and

fewer significant digits),
$$Z = \frac{P}{g(P)} \begin{pmatrix} -556 & 0 \\ 0 & -1000 \end{pmatrix} + \frac{P^2}{g(P)} \begin{pmatrix} 4.139 & 1.480 \\ 0.485 & 10.369 \end{pmatrix} \text{ where } g(P) = 556 - 9.904 P + 0.0392 P^2. The roots $g(P) = 0$, and hence points of singularity of $A(p)$, are $P = 84.277$ and $P = 168.123$.$$

$$B_{22} = Z = (A_{22} - A_{21}A_{11}^{-1}A_{12}^{-1})^{-1}$$

$$B_{21} = -Z (A_{21}(A_{11}^{-1}))$$

$$B_{12} = -Z (A_{11}^{-1}A_{12}^{-1})$$

$$B_{11} = A_{11}^{-1} + (A_{11}^{-1}A_{12}^{-1}) Z (A_{21}A_{11}^{-1}).$$

If we denote the Z matrix as $Z = B_1 P/g(P) + B_2 P^2/g(P)$, the inverse of the matrix A(P) is $A^{-1}(P) = C_0 + C_1 P/g(P) + C_2 P^2/g(P)$, where C_0 , C_1 and C_2 are matrices of constants defined as follows:

$$c_0 = (\frac{A_{11}^{-1} & 0}{0})$$

$$c_1 = (\frac{(A_{11}^{-1}A_{12}) B_1(A_{21}A_{11}^{-1}) - (A_{11}^{-1}A_{12})B_1}{-B_1(A_{21}A_{11}^{-1})}$$
and
$$c_2 = (\frac{(A_{11}^{-1}A_{12}) B_2(A_{21}A_{11}^{-1}) - (A_{11}^{-1}A_{12}) B_2}{-B_2(A_{21}A_{11}^{-1})}$$

As a result of this derivation we see that the reduced form for this system of equations is $Y = (C_0 B + C_1 B P/g(P) +$ $C_2 B P^2/g(P)) X + A^{-1}$ (P) U, where Y, X, and U are vectors of endogenous, exogenous, and random disturbance variables and the B matrix (without subscript) refers to the matrix of the coefficients of the exogenous variables in the structural system. Obviously, this is not a linear system of equations involving the exogenous variables, and is definitely not the system of equations which were claimed to be used in the two stage estimation process. The equations in the stage one system actually used by Myers, et. al. were not all of the same form, viz. the per capita beef and pork consumption and the retail price of broilers all used per capita income, broiler consumption and pork storage holdings, while the other stage one equations used total values of these variables (the structural system used total pork storage holdings and per capita income and per capita chicken consumption). As a result, the

estimation process utilized by Myers can, at best, be described as an instrumental variables approach to the problem, and even this would probably stretch the literal definition of the process.

In this thesis I examined the forecasts which were generated by both his stage one equations and the forecasts which were generated by the structural model (as determined by the reduced form equations). In either format there were no lagged endogenous variables to affect the analysis.

Trierweiler-Hassler Monthly Model

The third monthly econometric model which was used in this analysis was developed by John Trierweiler and James Hassler at Nebraska (79, 80). Their model included retail demand equations for both beef and pork which were estimated from quarterly data, assuming that the per capita supplies were predetermined, and a number of other equations which related carcass and slaughter animal prices to the respective retail prices for beef and pork, these latter equations being estimated using monthly data. The structure of the model included no lagged variables in the analysis and so could be represented in the form A Y(t) = B X(t) + U(t). The model consisted of six equations explaining five endogenous variables (one endogenous variable was explained using two alternative functional forms) using five separate series of exogenous variables, which, together with a time trend and dummy variables for quarters, gave the X(t) vector a dimension of 10.

Crom Quarterly Model

The quarterly model which was analyzed in this thesis was that which Richard Crom of the U.S. Department of Agriculture published as Technical Bulletin No. 1426 (9). His is a recursive model of the beef and port subsector of the economy which he estimated by means of ordinary least squares over the period 1955 to 1966 (although for one set of equations the period 1957 to 1968 was used). There were twenty-five separate quarterly endogenous data series in this model, but more than that number of equations were estimated, since for some relations separate equations were estimated for each quarter of the year (not always containing the same explanatory variables). There was also an inventroy subsystem which contained five variables for which only annual observations are made. There were eleven series of exogenous variables used in the model, along with a time trend, dummy variables, and numerous restrictions to be mentioned below.

As the system is structured, it is an exceedingly complicated dynamic model. The quarterly relations contain endogenous variables lagged as many as five quarters, and the annual equations contain variables lagged as many as three years. There are two identities which state that one endogenous variable is the product of two other endogenous variables. Finally, when the system as estimated by Crom did not sufficiently approximate the actual market behavior in its original form, he began imposing additional restrictions on the response of the endogenous variables in various circumstances (the model as published contained 147 such restrictions, of which 128

were given explicit notice in the publication). The easiest way to express the flow of dependence within the model is in a figure such as he used to describe the model which I have reproduced here as Figure 1. Figure 1 has been reproduced from his bulletin with some modification to make it correspond with the published form of his model.

Unger Annual Model

The annual model which was analyzed in this thesis was constructed by Samuel Unger at Michigan State University as part of his dissertation research (81). He constructed an interdependent model describing the cattle and beef sector and then estimates it with a number of alternative estimators. 1

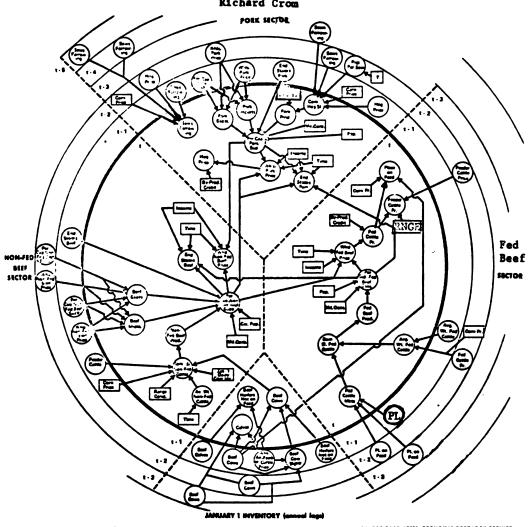
Schematically, Unger's model can be represented as AY(t) = BY(t-1) + CX(t) + U(t). The Y vector of endogenous variables is ten dimensional and the X vector of exogenous factors (including the intercept) has dimension of eight. No binary variables were included in his analysis.

Trend Models

Models of trend extrapolation are generally thought of as something akin to an intellectual "copout", an admission of ignorance

These were ordinary least squares, two stage least squares, Nagar's unbiased K-class, three stage least squares, iterated three stage least squares, and limited information single equation estimators. He used three methods as the intermediary step in the three stage process: two stage least squares (which is the commonly used intermediate step), unbiased K-class and limited information estimates. In my analysis of the effect of estimation method on forecast accuracy, I chose not to evaluate the latter two options in the three stage process.

QUARTERLY MODEL OF BEEF AND PORK SECTORS OF THE LIVESTOCK-MEAT ECONOMY
Richard Cross



U.S. DEPARTMENT OF AGRICULTURE

MEG. ERS 9448-40(5) ECONOMIC RESEARCH SERVICE

as to the forces affecting the market under study. Hildreth (35) commented to the effect that every relation which includes time as an explanatory variable is an unanswered challenge to econometricians. With that as a remark concerning the inclusion of a single trend variable as one of the exogenous variables within a simultaneous equations model, there is little question as to the potential response to a model which contains nothing but time (or functions of time) in an attempt to smooth, "explain", or forecast a series for a particular variable.

An alternative explanation for the existence of trend models is the relatively high cost of modelling, estimating, and interpreting the complicated interdependent systems of relationships which characterize most economic systems. Elementary economics tells us we should only act up to the point where the marginal benefit is no less than the marginal cost, in whatever the activity at hand, be it growing wheat or, as it were, applying economics.

Implicit in any trend analysis is the assumption of a stationary system. Although this assumption restricts the analysis somewhat, it is not as confining as one might suspect. It only means that those things which have been constant remain so, and those which have been changing, contine to do so in the same way.

As a particular example, consider the following equation which might typically be found in a dynamic economic system.

M

Y(t) = \(\Sigma_{k} \) \(Y(t-k) + \(\Sigma_{k} \) \(Sigma_{k} \) \(Y(t-k) + \(Sigma_{k} \) \) \(Y(t-k) + \(Sigma_{k} \) \) \(Y(t-k) + \(Sigma_{k} \) \) \(Y(t-k) + \(Sigma_{k} \) \(Y(t-k) + \(Sigma_{k} \) \(Y(t-k) + \(Sigma_{k} \) \) \(Y(t-k) + \(Sigma_{k} \) \(Y(t-k) + \(Sigma_{k} \) \) \(Y(t-k) + \(Sigma_{k} \) \(Y(t-k) + \(Sigma_{k} \) \) \

consider Y(t) and the a_k to be scalars and the B_j and the X(t) to be vectors. (This relation may actually be a part of a larger economic system, but that possible complication will be ignored for the present purposes). The solution to this equation is given by the sum of the general solution to the homogeneous part and a particular solution to the nonhomogeneous equation, subject to the initial conditions and the assumed time path of the exogenous variables (2, p. 192). The general solution to the homogeneous equation is $Y_h(t) = \sum_{k=1}^{m} c_k R_k^t$, where R_k is the k-th root of the algebraic equation $R^m - a_1 R^{m-1} - a_2 R^{m-2} - \dots - a_m = 0$. The m are assumed to be distinct. Note that these $a_k^{-1}s$ are the same a_k 's as appeared in the difference equation. The c_k 's are constants which are arbitrary until determined by the initial conditions on the y's. The determination of the particular solution is basically a matter of diligence and experience once the time $\sum_{j=0}^{n} B_{j}X(t-j)$ has been determined or path of the forcing functions assumed. Needless to say, this sort of solution process is quite arduous and becomes more so if the equation is part of a system of other similar equations. But whatever the specifics of the solution for the model, it can be said that there is a definite time path which is followed by the dependent variable which can be represented as Y(t) = f(t).

If all we are concerned about is simply projecting the time path of the variable in question within a fairly stable environment, it may be much easier (in a costs and returns sense) to use some method to approximate the time path f(t), than to attempt a direct analytical solution to the entire structural system. The question

then distills to one of determining an appropriate approximation method. Two commonly used ones are the Taylor series approximation and the Fourier series approximation. The effectiveness of these two methods in generating forecasts outside the estimation period will be investigated in this thesis, both in comparison with each other and as alternative maintained hypotheses to compare the econometric models with.

Taylor Series Approximation

The basic idea behind a Taylor series expansion of a function is the theorem (12, p. 82) which states: If a function f is continuous on the closed interval [a,b], then $f(x) = f(a) + \frac{f(k)}{k!}(a)$ $(X-a)^K + \frac{f(n)}{n!}(z)$ $(X-a)^n$, where z is some number in the open interval (a,x) and $f^{(k)}(a)$ is the k-th derivative of f evaluated at a. This implies that an n-th degree polynomial can be used to approximate an n-th order differentiable function of this type for variation within the interval of convergence. 1

Since we have posited a time dependence in the variation of the price series (of either an unspecified form or a too-complicated form) which we want to approximate by means of a Taylor series, the statistical model which we assume is of the form: $P(t) = a + b_1 t + b_2 t^2 + ... + b_n t^n + u(t).$ There is a direct correspondence between the b, coefficients and the i-th derivatives

In this context, the interval of convergence is taken to be those values of the independent variable for which the difference between the actual functional value and the value of the approximation is less than a pre-specified amount. In a more general context, it refers to the ranges of X's for which the power series converges, and hence, to those for which the limit of the remainder is zero as the degree of the polynomial increases without bound.

of the time series at the origin. The a coefficient (intercept) represents the sum of the value of the function at the origin and the average value of the remainder. The disturbance u(t) represents the deviation of the remainder at any time t from the average remainder for the observation period and is assumed to possess all the usual statistical properties. One should note that the frequently used linear trends are no more than polynomials of degree one (the simplest case).

One rather undesirable feature of a polynomial approximation is the fact that as the independent variable (t) becomes large, the approximation approaches either plus or minus infinity, depending on the sign of the highest order coefficient (b_n). This fact leads one to suspect that this means would not work very well as a way of generating intermediate run projections of bounded series. The only question of substantial interest in evaluating the forecasts generated by a polynomial approximation is the period of time between the sample period and the point at which the divergence of the series is apparent.

Fourier Series Approximation

To arrive at an approximation which does not diverge outside the sample period, one may use a series of bounded functions to approximate the actual function. Elementary functions which do possess the property of boundedness over the entire range of definition are the trigonometric functions (sin x and cos x). The theory of Fourier series developed around the question of when does an

infinite series of trigonometric functions converge, and what coefficients are necessary for that series to converge to a particular function. 1

If f(t) is a function which is integrable over the domain [0,p], the Fourier series corresponding to f(t) is defined as $\frac{a_0}{2} + \sum_{n=1}^{\infty} (a_n \cos{(2n \pi t/p)} + b_n \sin{(2n \pi t/p)}), \text{ where the coefficients } a_n \text{ and } b_n \text{ are defined by the following integrals:}$ $a_n = \frac{2}{p} \int_0^p f(t) \cos{(2n \pi t/p)} dt, \text{ for } n = 0,1,2,3,\dots \text{ and}$ $b_n = \frac{2}{p} \int_0^p f(t) \sin{(2n \pi t/p)} dt, \text{ for } n = 1,2,3,4,\dots$

This expansion can be used to interpolate any function which is integrable over an interval, or if the function under study is periodic, i.e. f(x+p) = f(x), it can be used to extrapolate future values of the function.

A point which is important enough that it bears repeating, is that the Fourier coefficients are no different than the coefficients which would be derived from ordinary least squares estimation of the trigonometric series from a sample period which is an integer multiple of the interval $[0, 2\pi]$ when the sums of squares and cross-products are replaced by the values of the corresponding integrals: If one were to estimate the function $Y(t) = a + b_1 \cos(t) + C_1 \sin(t) + b_2 \cos(2t) + C_2 \sin(2t) + U(t)$ over a sample period in which the time variable corresponds to the range

From another vantage point, it can be said that Fourier series theory provides the interpretation of the coefficients of the trigonometric series used to approximate a particular function.

0 to 2π , the least squares normal equations would be:

$$\begin{pmatrix} \mathbf{r} & \mathbf{1} & \mathbf{r}\cos(t) & \mathbf{r}\sin(t) & \mathbf{r}\cos(2t) & \mathbf{r}\sin(2t) \\ \mathbf{r}\cos(t) & \mathbf{r}\cos(t) & \mathbf{r}\sin(t) & \cos(t) & \mathbf{r}\cos(2t) & \cos(t) & \mathbf{r}\sin(2t) & \cos(t) \\ \mathbf{r}\sin(t) & \mathbf{r}\cos(t)\sin(t) & \mathbf{r}\sin^2(t) & \mathbf{r}\cos(2t) & \sin(t) & \mathbf{r}\sin(2t) & \sin(t) \\ \mathbf{r}\cos(2t) & \mathbf{r}\cos(t) & \cos(2t) & \mathbf{r}\sin(t) & \cos(2t) & \mathbf{r}\sin(2t) & \cos(2t) \\ \mathbf{r}\sin(2t) & \mathbf{r}\cos(t) & \sin(2t) & \mathbf{r}\sin(2t) & \mathbf{r}\sin(2t) & \cos(2t) \\ \mathbf{r}\sin(2t) & \mathbf{r}\cos(t) & \sin(2t) & \mathbf{r}\sin(2t) & \mathbf{r}\sin(2t) & \mathbf{r}\sin(2t) \\ \mathbf{r}\sin(2t) & \mathbf{r}\cos(t) & \sin(2t) & \mathbf{r}\sin(2t) & \mathbf{r}\sin(2t) & \mathbf{r}\sin(2t) \\ \mathbf{r}\sin(2t) & \mathbf{r}\cos(t) & \sin(2t) & \mathbf{r}\sin(2t) & \mathbf{r}\sin(2t) & \mathbf{r}\sin(2t) \\ \end{pmatrix}$$

If the time interval between observations is small enough that the discrete sums on both sides of the equation can be replaced by the corresponding integrals 1 over the sample interval $[0, 2\pi]$, the normal equations become:

From this we observe that these estimated least squares coefficients are precisely the coefficients which define the Fourier series for the variable (function) y(t). The mathematical fact which allows this process to simplify in this manner is that the trigonometric functions and their harmonics are orthogonal (12, p. 221). This means that for all distinct integers m and n the following integrals are all zero:

$$\int_0^{2\pi} \cos(mt) \cos(nt) dt = \int_0^{2\pi} \cos(mt) \sin(nt) dt = \int_0^{2\pi} \sin(mt) \sin(nt) dt = 0$$

One would recall that the process of integration obtains the limit of such discrete sums as the interval between successive observations goes to zero.

(when m = n, the first and last integrals are equal to π and the middle integral is still zero).

The existence of the Fourier series is simply a matter of definition (i.e. it is defined whenever f(t) is integrable over the interval [0, p]), but the convergence of the series, in particular its convergence to f(t), is a matter which has to be established in each case. The conditions (in addition to integrability) under which the Fouries series converges to the original function are that there are only a finite number of maxima and minima over a finite interval and that there exist at most a finite number of (finite) discontinuities (at which the series converges to the average of the right- and left-hand limits) (9, p. 3-14). Generally, these criteria are fulfilled for most empirical time series.

Once it has been decided to use a Fourier series to approximate the time series of prices for beef cattle and hogs, there is the question as to the period to use as the basis for estimating these Fourier series for each price series. For the prices of beef cattle, carcasses and retail cuts, a cycle with a period of ten years was assumed. This corresponds with the generally assumed cycle in cattle production and is the same period assumed by another researcher in describing long term price cycles (21, 22).

The basic hog and pork price cycle was assumed to be four years long, with an "overtone" of length eight years. The four year cycle was derived from a cobweb-type model of adjustment in an article by Arnold Larson (49). The eight year cycle was added to try to capture some of the longer term swings in the price behavior.

For all except the annual relations an attempt was made to include the sine and cosine terms with period one year in order to quantify the pattern of price variation within the year.

Since the purpose of the trend analysis is to compare it as an explanatory (or predictive) hypothesis for the beef prices with the econometric models of price structure, the following guidelines were developed for the use of these approximation methods in this thesis: The same sample period would be used to estimate the polynomial and trigonometric trend equations as was in the research which gave rise to the econometric models which are being studied. Since each added variable (power of t, or cos (nt)) when included in the equation to be estimated increases the explanatory power of that equation, at the cost of reduced degrees of freedom for error, it was decided to structure the equations so as to retain approximately the same number of error degrees of freedom as were present in the original econometric models. For the dependent variables in the Crom Model, the restrictions he imposed on the estimates of the particular endogenous variables were considered to reduce the error degrees of freedom by one for each such restriction.

Estimates of the Trend Equations

In this section of the discussion, I will present and briefly comment upon the polynomial and trigonometric trend approximating equations. The models to which these equations correspond are, in order, Hayenga and Hacklander, Myers, Trierweiler and Hassler, Crom and then Unger.

One word of caution should be uttered regarding the interpreation of the estimated coefficient standard errors, the standard error of estimate, and the t-ratios: The positive serial correlation of the disturbances indicated by the small values of the Durbin-Watson statistic causes the usual variance calculations (those presented in these tables) to be biased toward zero, so that the t-ratios will also be biased, but away from zero (24).

Corresponding to the Hayenga-Hacklander Model. -- In the Hayenga and Hacklander model the two price variables are the price of choice 900-1100 lb steers at Chicago and the price of Nos. 2-3 200-220 lb. barrows and gilts also at Chicago. The model as specified contained an average of sixteen coefficients per equation, with the two demand equations which were in proce dependent form, having sixteen and seventeen parameters in them. The polynomial trend equations were estimated as polynomials of fifteenth degree in teim as the independent variable. The estimated coefficients of these equations are presented in Table 3, in exponential form, together with their corresponding t-ratios. To illustrate the conversion of the exponential form of the coefficients to the form more frequently encountered, I will present two examples: The coefficient of T⁰ (i.e. the intercept) in the hog price equation is presented as .14959233E+02; this is to be read as .14959233 times ten raised to the power +02, or 14.959233. The coefficient of T4 in the same equation is -.67956878E-02 which is the same as -0.0067956878. For these and all other of the estimated equations the coefficient of determination, standard error of estimate and Durbin-Watson statistic are presented as measures descriptive of the residuals from the estimated equation (and not explicitly for purposes of hypothesis testing).

Table 3

Estimated Polynomial Trend Equations

Corresponding to Hayenga - Hacklander Model

Sample Period: April 1963 to June 1968, by Months

	Price of Nos. 2-3, 200-220 lb. Barrows and Gilts at Chicago		Price of Choice Slaughter Steers	
Exponent	(\$/Cwt	:)	(\$/Cwt)	
of Time	Coefficient	t-ratio	Coefficient	t-ratio
0	.14959233E+02	24.2819	.22804802E+02	61.8326
1	36234268E+00	-1.30 50	78339298E+00	-4.7129
2	.23731000E+00	3.1773	.69738854E-01	1.5597
3	.78890184E-02	0.4062	.30500484E-01	2.6233
4	6795687 8E-02	-3.2157	35859166E-02	-2.8344
5	.16382507E-03	0.3669	23282093E-03	-0.8709
6	.72752480E-04	1.6756	.56103967E-04	2.1584
7	52298938E-05	-2.2437	23424032E-05	-1.6786
8	17316589E-06	-0.4328	14059199E-06	-0.5870
9	.39426328E-07	1.2407	.20006625E-06	1.0516
10	23588428E-08	-1.6509	10433577E-08	-1.2198
11	.77559827E-10	1.9139	.31519119E-10	1.2992
12	15597670E-11	-2.1007	59635170E-12	-1.3416
13	.19176596E-13	2.2410	.69957902E-14	1.3656
- 14	13290387E-15	-2.3499	46699124E-16	-1.3792
15	.39896577E-18	2.4360	.13592876E-18	1.3864
R ²	0.9224		0.8656	
S.E.E.	1.2548 (47 degre	es of freedom)	0.7512 (47 deg	rees of freedom)
D.W.	1.1724		0.9305	

Time origin: T = 1 in Jenuary 1964.

The estimated trigonometric trend equations for the Hayenga-Hacklander model are presented in Tables 4 and 5. The hog price equation if in Table 4 and the cattle price equation directly corresponding to this model is in the first column of Table 5.

The equation in the second column of that table is a substitute estimate with the same dependent variable but a longer sample period. In this and all other tables of the trigonometric approximating equations, the coefficients are presented, as well as the amplitude for each cycle considered.

As is obvious from perusal of the coefficients, the cattle price equation which was estimated using the same sample period as the Hayenga-Hacklander model is unrealistic in terms of both the estimated amplitudes of the cycles (the unit of measurement is dollars per cwt.) and the intercept which is to be interpreted as the mean of the dependent variable. Of the following two explanations for this phenomenon, I suspect the second has more bearing on the issue than the first: First, as will be demonstrated below, the model which Hayenga and Hacklander estimated is dynamically unstable which may mean either that the market is unstable which might cause estimates of this type, or that the model itself is deficient in some way, in which case, this would have little bearing on the trigonometric

If $y = a \cos x + b \sin x$, then y is also equal to d cos (x-t) where the amplitude d is given by $d = (a^2 + b^2)^{1/2}$ and the phase angle t is given by $t = \arctan(b/a)$. The phase angle would only be useful in determining the relative displacements from the time origin of the cosine terms of different frequencies, hence was not presented explictly. The difference between the high and low points on the cycle is twice the amplitude.

Table 4

Estimated Trigonometric Trend Equations

Corresponding to Hayenga - Hacklander Model

Price of Nos. 2-3, 200-220 lb. Barrows and Gilts at Chicago (\$/Cwt)

Sample Period: April 1963 to June 1968, by Months

Period Cosine Sine Amplitude

Period	Cosine	Sine	Amplitude
Intercept	20.751 (0.435		
8 years	-2.26952 (0.2210)	0.94000 (0.7300)	2.45648
4 years	-3.64688 (0.4462)	-0.71660 (0.2604)	3.71662
2 years	1.73192 (0.2337)	0.34334 (0.2137)	1.76563
16 months	-0.56286 (0.2166)	-0.08602 (0.2179)	0.56940
12 months	-0.76331 (0.2189)	-0.65761 (0.2186)	1.00751
9.6 months	-0.56073 (0.2166)	-0.27352 (0.2161)	0.62389
8 months	0.23860 (0.2147)	0.71527 (0.2147)	0.75401
6.85 aonths	-0.19733 (0.2122)	-0.03386 (0.2118)	0.20022
R ²	0.93	61	
S.E.E.	1.15	09 (46 degrees o	f freedom)
D.W. The numbers in p	1.22 parentheses are	68 the coefficient s	anderd errors.

Time origin: T = 1 in January 1964.

Table 5

Estimated Trigonometric Trend Equations

Corresponding to Hayengs - Hacklander Model

Price of Choice 900-1100 lb. Steers at Chicago , by Months (\$/Cwt)

* Sample Period: April 1963 to	June 1968	@Sample Per	riod: Jan	w ary 1957 t	o December 1969
Period Cosine Sine	Amplitude	Period	Cosine	Sine	Amplitude
Intercept -4290.58135 (4150.3002)		Intercept		05737 0815)	
10 years 3137.548 7319.509 (2751.12) (7126.33)	7963.63078	10 years	-0 09091 (0.1171)	-1.79577 (0.1135)	1.79808
5 years 4300.821 -4508.904 (4405.52) (3972.55)	623 1.15311	5 years	-0.297 68 (0.1140)	0.11612 (0.1166)	0.31953
40 months-3824.264 -1442.540 (3402.35) (1782.57)	4087.28755	40 wonths	0.70364 (0.1161)	1.70686 (0.1145)	1.84621
30 months 78.306 2191.865 (399.19) (1985.40)	2193.26352	30 months	-0.52553 (0.1151)	0.29232 (0.1154)	0.60136
2 years 840.868 -380.470 (786.01) (271.51)	922.93895	2 years	-0.00432 (0.1151)	0.18099 (0.1154)	0.18104
20 months -199.896 -193.018 (146.97) (193.21)	277.87431	20 months	0.64688 (0.1157)		0.64724
17+months -18.908 42.704 (22.81) (32.07)	46.70317	17+months	-0.00162 (0.1149)	0.486 99 (0.1156)	0.48699
1 year -0.954 0.336 (0.604) (0.477)	1.01145	15 months	0.01909 (0.1153)	-0.04381 (0.1150)	0.04779
2 0.8719 8.E.E. 0.7415 (46 degree	es of	13+months	-0.09482 (0.1152)		0.27042
D.W. 1.0224 fre	eedom)	1 year	0.13277 (0.1149)		0.14100
2		11-months	0. 89822 (0.1149)	0.16141 (0.1144)	0.91261
The numbers in parentheses as coefficient standard errors. * Time origin: T = 1 in Jac		10 months	0.454 8 1 (0.1127)	0.16251 (0.1130)	0.48297
@ Time origin: T = 1 in Ja	muary 1962.	R ²	0.8594		
•		S.E.E.	0.9702	(107 deg	rees of freedom)
		D.W.	0.6129		Tiesdom)

estimates. The second hypothesis regarding the unrealistic coefficients is that the basic period of the assumed function is longer than the sample period. I have not uncovered a reference which deals with the convergence (or failure to converge) of Fourier-type series where the coefficients are integrals identical with those of the Fourier series except that the interval over which they are integrated is not an integer multiple of the period of the function. Because the likelihood of the non-convergence of such a series appears substantial, I feel that this latter is the more credible of the explanatory hypotheses.

An observation on the relative degree of fit of the trend approximations compared with the structural equations of the model is that the R² of the trend models was only between .005 and .047 less than the proportion of explained variation corresponding to the demand equations for the particular commodities (which had the best fits of the equations of the model).

Corresponding to the Myers Model. -- In the Myers model, the endogenous price variables are the weighted average price of all grades of steers sold out of first hands in Chicago, Omaha and Sioux City, the eight market weighted average price of barrows and

In some unpublished previous work, I observed a trigonometric model for a different price series which generated coefficients similarly unstable and the sample period was shorter than the period of the model. However, I also obtained results which appeared reasonable, notwithstanding a sample period shorter than the period of the cycle.

This situation covers the case at hand, as well as the case where there are more than n complete cycles, but less than n+1 cycles in the sample period.

gilts, the average retail price of choice carcass cuts of beef in U.S. urban areas, the average retail price of retail pork cuts and sausage in U.S. urban areas, and the average retail price of frying chicken in retail stores in U.S. urban areas. All the prices were deflated to eliminate the influence of general trends of prices:

The farm level prices were divided by the wholesale price index with the base years 1957-59 = 100, and the retail prices were divided by the consumer price index with the same base period.

Since the average number of parameters per equation in the Myers model was fourteen, the polynomial trend equation was estimated by a polynomial of degree thirteen and the trigonometric trend equations consisted of seven pairs of sine and cosine functions. Because of an obvious downtrend in the retail price of frying chickens, a linear time trend was included in this equation. One should note that the independent variables in the polynomial equations are time divided by 100 raised to the appropriate power, rather than time alone raised to the power. 1

The estimated polynomial trend equations corresponding to the prices in the Myers model are given in Tables 6, 7 and 8 and the trigonometric trend equations are presented in Tables 9, 10 and 11. The retail and farm level beef prices are in Tables 6 and 9, the retail and farm level hog prices are presented in Tables 7 and 10, and the retail price of frying chicken are presented in Tables 8 and 11.

This transformation was necessary to allow observation of the coefficients of the higher order terms. For example, if time alone were the argument, the coefficient of T_{-23}^{13} in the equation for the retail beef price would be 3.6 times 10^{-23} .

Table 6
Estimated Polynomial Trend Equations
Corresponding to Myers Model

	Price of Beef		Three Market Price	
Exponent o			Deflated by W.P.I. (\$/Cut)	(1957-59 base)
(Time/100)		t-ratio	Coefficient	t-ratio
0	74.26443657	117.5862	22.74260519	59.1572
1	-43.45149882	-6.7256	-24.47224749	-6.2228
2	-18.21462359	-0.4557	53.60428051	2.2032
3	1464.65842393	6.3418	1042.88517568	7.4183
4	3040.44951987	5.2153	1080.21420574	3.0440
5	-12566.12527251	-4.5118	-10589.97091675	-6.2465
6	-44299.36641979	-8.1105	-27794.84918022	-8.3600
7	-10140.94931245	-1.2392	4489.15401316	0.9012
8	141063.85958862	4.9781	109011.24372482	6.3199
9	275958.14494324	6.4660	191653.18920517	7.3773
10	249990.13731003	7.1619	166043.17642593	7.8148
11	124347.19972420	7.5794	80421.51545906	8.0530
12	32855.9001 3885	7.8587	20866.15546513	8.1992
13	3617.26791179	8.0556	2266.89920938	8.2936
2	0.8927		0.8608	
S.E.E.	2.6968 (202 deg	rees of freedom)	1.6416 (202 (degrees of freedom)
D.W.	0.4520		0.3686	

Time origin: T = 1 in January 1964

Table 7
Estimated Polynomial Trend Equations
Corresponding to Myers Model

		Price of Pork Cuts and Sausage at Retail		ows and Gilts Markets
Exponent of		P.I. (1957-59 base) /lb.)	Deflated by W.P.: (\$/Cw	I. (1957-59 b ase) t)
(Time/100)	Coefficient	t-ratio	Coefficient	t-ratio
0	52.07844992	63.7992	14.41254284	27.6190
1	-56.46173995	-6.7618	-22.18714805	-4.1564
2	186.39684981	3.6082	186.87682634	5.6587
3	2605.81573415	8.7297	1442.91201967	7.5615
4	1812.07796925	2.4049	-206.84803542	-0.4294
5	-23856.72619772	-6.6274	-15218.79319358	-6.6134
6	-52119.69294930	-7.3830	-25606.21305084	-5.6740
7	19166.76462984	1.8121	22572.10520124	3.3383
8	196863.26084137	5.3752	119265.12522888	5.0939
9	303631.69908905	5.5045	165498.88009644	4.6933
10	236289.15169525	5.2376	120272.51917839	4.1703
11	103476.46707535	4.8800	49626.08676147	3.6610
12	24345.78279 686	4.5055	11013.57065773	3.1883
13	2402.54230148	4.1397	1022.60519701	2.7562
R ²	0.6793		0.6816	
S.E.E.	3.4855 (202	degrees of freedom	2.2282 (202	degrees of freedom)
D.W.	0.4902		0.3392	

Time origin: T = 1 in January 1964.

Table 8 Estimated Polynomial Trend Equations Corresponding to Myers Model

Average Retail Price of Frying Chicken Deflated by C.P.I. (1957-59 base) (¢/lb.)

Exponent of	(¢/10.)	
(Time/100)	Coefficient	t-ratio
0	36.48191563	62.4337
1	-15.68856975	-2.6247
2	-36.94366262	-0.9990
3	288.34719814	1.3494
4	1409.80886060	2.6138
5	-209.13836120	-0.0812
6	-9102.76802707	-1.8013
7	-15273.51571703	-2.0173
8	-2610.82223183	-0.0996
9	18760.06170797	0.4751
10	24397.19566965	0.7555
11	14034.21023107	0.9246
12	4011.28916478	1.0370
13	463.54278534	1.1158
R ²	0.9674	
S.E.E.	2.4951 (202 degrees of freedom)	
D.W.	0.6482	

Time origin: T = 1 in January 1964

Table 9

Estimated Trigonometric Trend Equations

Corresponding to Myers Model

Price of Beef at Retail			Three Market Price of Beef Cattle				
Deflate Period	d by C.P.I Cosine	.(1957-59 Sine	base) (¢/lb.) Amplitude	Deflated Period	by W.P.I. Cosine	(1957-59 b Sine	ase) (\$/Cyt) Amplitude
Intercept		7660 956)		Intercept	26.18 (0.2		
10 years	-2.40950 (0.5719)	-7.18848 (0.5472)	7.58155	10 years	-1.04977 (0.3371)	-3.35579 (0.3225)	3.51615
5 years	-1.13019 (0.5507)	-0.29168 (0.5692)	1.16722	5 years	-0.59730 (0.3246)	0.15935 (0.3355)	0.61819
40 months	-1.94470 (0.5646)	0.68567 (0.5546)	2.06204	40 months	-1.11222 (0.3328)	0.30443 (0.3269)	1.15313
30 months	-0.46907 (0.5565)	-0.29684 (0.5586)	0.55511	30 months	-0.49525 (0.3281)	0.27258 (0.3293)	0.56531
2 years	-0.49967 (0.5502)	0.75917 (0.5577)	0.90885	2 years	-0.05599 (0.3243)	0.29644 (0.3287)	0.30168
20 months	-0.10673 (0.5512)	0.25491 (0.5480)	0.27635	20 months	-0.19097 (0.3249)	0.15343 (0.3230)	0.24497
l year	0.25419 (0.5413)	-0.87240 (0.5424)	0.90867	l year	0.07840 (0.3191)	-0.77883 (0.3197)	0.78276
R ²	0.	5361		R ²	0.4	4356	
S.E.E.	5.	6221 (201	degrees of	S.E.E.	3.:	3140 (201	degrees of
D.W	. ú.	0 584	freedom)	D.W.	0.0	073 <i>C</i>	freedom)

Numbers in parentheses are coefficient standard errors.

Time origin: T = 1 in January 1964

Table 10

Estimated Trigonometric Trend Equations

Corresponding to Myers Model

Eight Market Price of Barrous and Gilts Deflated by W.P.I. (1957-59 base) (\$/Cwt)			Retail Price of Pork Cuts and Sausage Deflated by C.P.I. (1957-59 base) (¢/lb.)			_	
Period	Cosine	Sine	Amplitude	Period	Cosine	Sine	Amplitude
Intercept		0 390 031)		Intercept	59.93 (0.33		
8 years	-1.05848 (0.2952)	0.15006 (0.2786)	1.06907	8 years	-2.10833 (0.4627)	0.46703 (0.4366)	2.15943
4 years	-3.08353 (0.2871)	-0.37184 (0.2856)	3.10587	4 years	-4.25151 (0.4500)	-1.55618 (0.4476)	4.53082
2 years	-0.00903 (0.2850)	-0.05201 (0.2855)	0.05279	2 years	-0.02127 (0.4466)	-0.50154 (0.4475)	0.50199
16 months	0.03229 (0.2852)	-0.13973 (0.2850)	0.14341	16 months	0.19957 (0 4471)	-0.43405 (0.4467)	0.47773
1 year	-1.36962 (0.2049)	-0.51349 (0.2852)	1.46271	l year	-1.44032 (0.4465)	-1.69000 (0.4470)	2.22050
9.6 month	s-0.23007 (0.2851)	-0.12025 (0.2849)	0.25960	9.6 month	0.10279 (0.4469)	-0.30452 (0.4465)	0.32141
8 months	-0.0/;048 (0.2841)	-0.00833 (0.2845)	0.04143	8 months	-0.25130 (0.4453)	-0.09783 (0.4459)	0.26967
_R 2	0.	4465		R ²	0.	4403	
S.E.E.	2.	9453 (201	degrees of freedom)	S.E.E.	4.	6163 (201	degrees of freedom)
D.W.	0.	1552	ireecom)	D.W.	0.	2413	TTEEGOM)

Numbers in parentheses are coefficient standard errors.

Time origin: T = 1 in January 1964.

Table 11

Estimated Trigonometric Trend Equations

Corresponding to Myers Model

Average Retail Price of Frying Chicken Deflated by C.P.I. (1957-59 base) (¢/lb)

Period	Cosine	Sine	Amplitude
Intercept	35.5717 4 (0.512 2)		
Time	-0.20625 (0.0341)		
5 years	-0.59659 (0.3570)	0.72347 (0.3640)	0.93773
30 months	-0.35819 (0.3602)	-1.45694 (0.3612)	1.50032
20 months	-0.15553 (0.3618)	-0.21669 (0.3590)	0.26673
15 months	0.08716 (0.3611)	0.39823 (0.3589)	0.40765
1 year	-0.81505 (0.3598)	-0.09434 (0.3605)	0.82050
10 months	0.09399 (0.3595)	-0.58984 (0.3601)	0.59728
8.57 months	0.04694 (0.3593)	0.16674 (0.3579)	0.17322
R ²	0.9287		
S.E.E.	3.7072	(200 degre	es of freedom)
D.11.	0.2779		

Numbers in parentheses are coefficient standard errors.

Time origin: T = 1 in January 1964.

To indicate the relative degree of fit, during the sample period, the structural equations generally had the highest values of R², with the polynomial trend next, following by the stage one equations that Myers used, and finally by the trigonometric trend equations. The exceptions to the rule were hog and pork prices, where the stage one equations fit better than the polynomial trend equations.

Corresponding to the Trierweiler-Hassler Model. -- The Trierweiler-Hassler model was structured to explain the variation in the prices of choice 900-1100 lb. slaughter steers at Omaha, choice 600-700 lb. (steer) beef carcasses at Chicago, and the retain price of beef, together with the price of nos. 1-3 220-240 lb. barrows and gilts at Omaha and the retail price of pork (excluding lard). The retail price series were both quarterly variables, and the reunaining series were reported monthly. The structural equations explaining the quarterly variables required the estimation of six, and in the other case seven, parameters. In three of the monthly relationships, three parameters were estimated, and in the fourth, Four. The polynomial trend equations were estimated as cubic equations for the monthly series and of degree six for the quarterly Series. The trigonometric trend equations contained two pairs of trigonometric functions (three in the case of the quarterly relations) in addition to the intercept term. It might be noted that the trigonometric relations for the price of slaughter steers and for beef carcasses does not contain an annual component to the cycle. The component corresponding to a five year sub-cycle was chosen Over the annual component based on the insignificance of the annual Component of the cycle.

The polynomial trend equations are presented in Tables 12 and 13, with the trigonometric equations in the next three numbered tables. Tables 12 and 14 contain the estimates for the quarterly retail beef and pork prices. Tables 13 and 15 contain the equations estimated for the price of beef carcasses and the price of slaughter steers. The equations for the price of Omaha barrows and gilts are in Tables 13 and 16.

The structural equations fit the sample data much better than either of the trend models for the monthly price sereis. For the quarterly price series the polynomial trend equations fit marginally better than the structural equations. In almost all cases the polynomial trend model fit the sample data better than did the trigonometric trend.

Corresponding to the Crom Model. -- The endogenous price of choice grade steers at twenty markets, the weighted average price of choice grade carcasses at New York, Chicago, Los Angeles, San Francisco, and Seattle (less than carlot basis), the price of good and choice 500-800 lb. feeder steers at Omaha, the price of utility cow beef at New York, the eight market weighted average price of barrows and gilts, and the weighted average of wholesale prices of individual pork products at Chicago. All of these variables were observed quarterly.

The typical quarterly relationship in the Crom model contained slightly more than seven parameters and had ten restrictions

¹ This figure is arrived at by considering the relationships where separate estimates were obtained in each quarter as being equivalent to a single equation in which both slopes and intercepts were allowed to vary over subsets of the sample. This underestimates

Table 12

Estimated Polynomial Trend Equations

Corresponding to Trierweiler - Hassler Model

	Retail Price of Beef (¢/lb.)		Retail Price of Pork (¢/lb.)	(Excluding Lard)	
Exponent of (Time / 10)	Coefficient	t-ratio	Coefficient	t-ratio	
0	79. 54647007	103.9495	55.67102063	56.6509	
1	-0.86992951	-0.5688	-2.19417321	-1.1172	
2	3.658745 05	1.4507	18.80487956	5.8062	
3	3.77505053	1.5638	19.18893340	6.1898	
4	-0.14452996	-0.1041	-5.54647561	-3.1113	
5	-1.42378125	-1.0888	-9.64289214	-5.7424	
6	-0.42940667	-1.5132	-2.20881266	-6.0612	
R ²	0.7664		0.8139		
S.E.E.	2.1442 (33 degrees	s of freedom)	2.7536 (33 degree	s of freedom)	
D.W.	1.0036		1 5760		

Table 13

Estimated Polynomial Trend Equations

Corresponding to Trierweiler - Hassler Model

Carcasses at Chicago	39.03241635 - 0.10184343 T + 0.00231009 T ² + 0.00004303 T ³ (111.7277) (-9.0866) (7.7945) (9.0396) $R^{2} = 0.4706 \text{S.E.e.} = 2.3764 \text{D.w.} = 0.2813$
Steers at Omaha	24.07463973 - 0.04853323 T + 0.00127596 T ² + 0.00002404 T ³ (91.1741) (-5.7291) (5.6961) (6.6800) R ² = 0.2757 S.E.E. = 1.7961 D.W. = 0.2262
Gilts at Omaha	18.12063357 + 0.09144270 T + 0 00052467 T ² - 0.00001232 T ³ (44.4561) (6.9926) (1.5173) (-2.2183) R ² - 0.3417 S.E.E 2.7726 D.W 0.1934

128 error degrees of freedom in each equation.

The numbers in parentheses are the t-ratios for the coefficients.

Time origin: T = 1 in January 1964.

Table 14

Estimated Trigonometric Trend Equations

Corresponding to Trierweiler - Hassler Model

	Ret ail Beef Price (¢/lb)				Retail Pork Price (Excluding Lard) (¢/lb)			
Period	Cosine	Sine	Amplitude	Period	Cosine	Sine	Amplitude	
Intercept	80.18 (0.65	-		Intercept	5 9. 767 (0.620			
10 years	0.43187 (0.9329)	►0.96347 (0.9329)	1.05583	8 years	-1.19720 (0.9121)	3.00501 (0.8354)	3.23472	
5 years	-0.12763 (0.9329)	1.51432 (0.9329)	1.51969	4 years	-4.00467 (0.874 3)	-2.85365 (0.8543)	4.91739	
l year	0.40000 (0.9329)	0.41000 (0.9329)	0.57280	l year	0.39406 (0.8461)	-1.58241 (0.8461)	1.63073	
R ²	0.	1156		R ²	0.6	5500		
S.E.E.	4.	1719 (33	degrees of freedom)	S.E.E.	3.7	7764 (33 d	egrees of freedom)	
D.W.	0.	3692		D.W.	0.0	5728		

Numbers in parentheses are coefficient standard errors.

Table 15

Estimated Trigonometric Trend Equations

Corresponding to Trierweiler - Hassler Model

Choice 600-70	0 # Steer (\$/C		ice, Chicago	Choice	900-1100 # (\$/C		e, Omaha
Peri od	Cosine		Amplitude	Period	Cosine	Sine	Amplitude
Intercept		4331 111)		Intercept	25.18 (0.16		
10 years	-2.86167 (0.3010)	-1.44457 (0.2958)	3.20561	10 years	-1.37406 (0.2321)	-0.55949 (0.2280)	1.48360
5 years	0.39638 (0.3046)	0.27475 (0.2912)	0.48229	5 years	0.20477 (0.2348)	0.08375 (0.2245)	0.22124
R ²	0.	4662		R ²		2402	
S.E.E.	2.	3958 (127	degrees of	S.E.E.	1.8	8469 (127	degrees of freedom)
D.W.	0.	2799	freedom)	D.W.	0.	1 8 57	

The numbers in parentheses are the coefficient standard errors.

Time origin: T - 1 in January 1964.

Table 16

Estimated Trigonometric Trend Equations

Corresponding to Trierweiler - Hassler Model

Sample Period: 1957 to 1967, by Months
Price of Nos. 1-3, 220-240 lb. Barrows and Gilts, Omaha
(\$/Cwt)

	(4/ 011 - /		
Period	Cosine	Sine	Amplitude
Intercept	18.24373 (0.2333)		
4 years	-2.71092 (0.3282)	-0.94155 (0.3310)	2.86977
l year	-0.83676 (0.3277)	-0.63672 (0.3279)	1.05147
R ²	0.3981		
S.E.E.	2.6617	(127 degre	es of freedom)
D.W.	0.1801		

The numbers in parentheses are the coefficient standard errors.

Time origin: T = 1 in January 1964.

imposed upon it by the so-called "operating rules" which were arrived at after estimation for purposes of improving the performance of the model during his validation period. The subset of price variables of the model had a similar number of parameters per equation (7.5), but averaged only a bit less than five restrictions per variable. When the trend models were specified, the result was that the polynomial approximations were specified with error degrees of freedom equivalent to the typical quarterly relation in the model (i.e. a polynomial of degree sixteen was specified), and the trigonometric trend equations were specified more nearly like the price equations of the model (five pairs of sine and cosine functions were included, along with an intercept).

The estimated polynomial trend equations corresponding to the Crom model are presented in Tables 17, 18 and 19. The estimated trigonometric trend equations are presented in Tables 20, 21 and 22. Tables 17 and 20 contain the estimated equations describing the wholesale prices of fed (choice grade) and nonfed (utility grade) beef carcasses. The equations describing the trend relationships involving the slaughter and feeder steer prices are in Tables 18, 19 and 21. The prices at the wholesale and farm levels for hogs and pork are given in Tables 19 and 22.

The degree of explanation during the sample period is not significantly different between the structural model and the polynomial trend model, with the trigonometric trend model explaining about twenty percent less of the variation of prices than the other models.

the number of constraints on the data in that not always are the same variables assumed to affect the dependent variable in different quarters of the year.

Table 17

Estimated Polynomial Trend Equations

Corresponding to Crom Simulation Model

	Five Market Wholesale Price of Choice Beef Carcasses (\$/Cwt)		Price of Utility at New 1 (\$/Cw	l'ork
Exponent of (Time/10)	Cocfficient	t-ratio	Coefficient	t-ratio
0	39.23259507	41.4545	29.01807929	40.1653
1	2.18096777	0.3755	-7.81065612	-1.7615
2	25.02384718	1.2137	5.24063487	0.3330
3	-13.55352224	-0.1907	34.90446897	0.6432
4	-3.17692040	-0.0287	53.21789108	0.6291
5	30.91858055	0.1032	-42.72115294	-0.1868
6	-157.61555137	-0.4979	-183.60300151	-0.7597
7	-148.37667993	-0.3350	- 75.13 9 12296	-0.2222
8	256.24698404	0.3927	190.69845625	0.3828
9	367.80439 530	1.2469	222.23613558	0.9870
10	25.69 36935 9	0.0710	31.57240013	0.1143
11	-224.09226772	-0.5549	-93.62086531	-0.3037
12	-188.31574659	-0.8609	-80.64571694	-0.4830
13	-75.18982412	-1.0799	-32.09927221	-0.6039
14	-16.73949883	-1.2554	-7.11812879	-0.6993
15	-2.00410556	-1.4028	-0.85035188	-0.7797
16	-0.10102973	-1.5292	-0.04284127	-0.8494
a ²	0.8444		0.9407	
S.E.E.	1.6/26 (27 degr	ees of freedom)	1.2768 (27 degre	es of freedom)
D.U.	2.3747		2.3008	

Table 18

Estimated Polynomial Trend Equations

Corresponding to Crom Simulation Model

Sample Period: 1955 to 1966, by Quarters

	Twenty Market Average Price of Choice Grade Steers (\$/Cwt)		Average Price of Good and Choice 500-800 lb. Feeder Steers, Omaha (\$/Cwt)	
Exponent of (Time/10)	Coefficient	t-ratio	Coefficient	t-ratio
0	21.98 64 8 980	35.8453	21.36493299	50.1566
1	2.50169507	0.6645	-10.47419729	-4.0063
2	22.76 59725 9	1.7037	24.72366389	2.6642
3	-15.43054031	-0.3349	65.52407141	2.0480
4	-32.78097522	-0.4564	-37.55666659	-0.7530
5	25.72220891	0.1325	-187.81927765	-1.3929
6	-26.22542929	-0.1278	-68.82075661	-0.4830
7	-55.01168272	-0.1916	222.68872327	1.1170
8	98.95872124	0.2340	256.50154717	0.8733
9	153.20783325	0.8014	20.32569029	0.1531
10	3.11879280	0.0133	-148.85353096	-0.9138
11	-110.88038660	-0.4237	-135.57713332	-0.7460
12	-92.35234346	-0.6514	-61.49479149	-0.6246
13	-37.01697881	-0.8203	-16.67640772	-0.5321
14	-8.28156454	-0.9583	-2.74474704	-0 4574
15	-0.99585043	-1 0755	-0 25404256	-0.3951
16	-0.05038631	-1 1767	-0.01017687	-0.3422
R ²	0.8645		0.9661	
S.E.E.	1 0840 (27 degr	ees of freedom)	0.7528 (27 degre	es of freedom)
D.0.	2.3057		2.2254	

Table 19

Estimated Polynomial Trend Equations

Corresponding to Crom Simulation Model

P	Average Price of Wholesale Pork Products at Chicago (\$/Cwt)		Average Price of Barrows and Gil at Eight Markets (\$'Cwt)		
Exponent of (Time/10)	Coefficient	t-ratio	Coefficient	t-ratio	
0	39.83063421	30 9920	15.09957744	22.3712	
1	3.27876506	0.4157	2.37664597	0.5737	
2	8.26170252	0.2951	13.73501485	0.9341	
3	-26.88090324	-0.2785	-4.29564832	-0 .0847	
4	90.97325320	0.6046	15.97348436	0.2021	
5	399.45422717	0.9819	165.80027862	0.7760	
6	148.01379465	0.3443	117.56508201	0.5207	
7	-722.99661210	-1.2020	-303.63425100	-0.9612	
8	-912.11377454	-1.0292	-484.51039466	-1.0410	
9	-105.52988935	-0.2635	-114.89885991	-0.5462	
10	567.86015293	1.1554	271.28665130	1.0510	
11	553.393 86533	1.0092	302.35815712	1.0499	
12	262.27395861	0.8830	153.76009927	0.9857	
13	73.39 46305 2	0.7762	45.49518929	0.9162	
14	12.34519609	0.6818	8.05157 139	0.8467	
15	1,15803459	0.5969	0.79387804	0.7792	
16	0.04667000	0 5202	0 03367125	0.7146	
R ²	0.8385		0 9133		
S.E.E.	2.2713 (27 degr	ees of freedom)	1.1929 (27 degre	es of freedom)	
D.S.	2.3816		2 3503		

Table 20
Estimated Trigonometric Trend Equations
Corresponding to Crom Simulation Model

Wholesale		Choice Beef Cwt)	Caicasses	Price of	Utility G		t New York
Period	Cosine	Sine	Amplitude	Period	Cosine	Sine	Amplitude
Intercept	42.73 (0.38			Intercept	32. 056		
	(0.30	,,,,			(0.37)	/1)	
10 years		-1.22612	2.67891	10 years	-3.30143		3.90339
	(0.5547)	(0.5407)			(0.5398)	(0.5262)	
5 years	1.09833	-0.79358	1.35503	5 years	1.56404	-1.25367	2.00447
-	(0.5542)	(0.5401)		•	(0.5395)	(0.5257)	
40 months	-1 44511	0.68764	1.60038	40 months	-1 41521	1.14720	1.82178
40 monens	(0.5393)	(0.5533)	1.00036	40 MONTHS	(0.5249)	(0.5386)	1.02170
30 months	-0.91171 (0.5458)	0.53414 (0.5448)	1.05666	30 months	-0.29548 (0.5313)	-1.07882 (0.5302)	1.11855
	(000,00)	(000)			(0.5525)	(0,000,	
l year	0.19074	0.33078	0.38183	l year	1.14502		1.25739
	(0.5396)	(0.5396)			(0.5252)	(0.5252)	
2				_ 2			
R T	0.5	669		R T	0.7	319	
S.E.E.	2.5	24 2 (33 de		S.E.E.	2.4	569 (33 de	grees of
D.W.	1.0	919	freedom)	D.W.	0.48	8 70	freedom)

The numbers in parentheses are the coefficient standard errors.

Table 21
Estimated Trigonometric Trend Equations
Corresponding to Crom Simulation Model

Twenty Mark	et Price o (\$/Cwt		Grade Steers	Price of G	ood & Choic (Omah (\$/Cw	a) ·	# Feeder Steers
Period	Cosine	Sine	Amplitude	Period	Cosine	#1ne	Amplitude
Intercept	24.83 (0.26			Intercept	24.3 25 (0.281		
10 years	-1.73893			10 years			3.02558
	(0.3751)	(0.3656)			(0.4024)	(0.3921)	
5 yerr.		-0.50182	0.73961	5 years	1.43239	-1.04648	1.77394
	(0.5740)	(0.3 652)			(0.4010)	(0.3917)	
40 months	-1.13675			40 months	-1.57493		1.68847
	(0.3647)	(0.3742)			(0.3911)	(0.4013)	
30 months	-0.59791			30 months		-0.52570	0.69681
	(0.3691)	(0.3684)			(0.3959)	(0.3951)	
l year		0.14418	0.20020	l year	0.58290 (0.3914)	0.06307 (0.3914)	0.58630
	(0.3649)	(0.3649)			(0.3914)	(0.3914)	
_{3.} 2	a	5895		_R 2	0.75	51	
S.E.E.			1	S.E.E.	1.83		grees of
		\	degrees of freedom)			•	freedom)
D.W.	0.	9330		D.W.	0.38	45	

The numbers in parentheses are the coefficient standard errors.

Table 22

Estimated Trigonometric Trend Equations

Corresponding to Crom Simulation Model

Wholesale Price of Pork Products, Chicago (\$/Cwt)			Eight	Market Bar (\$/C	row and Gil	t Price	
Period	Cosine	Sine	Amplitude	Period	Cosine	Sine	Amplitude
Intercept	43.10 (0.52			Intercept	17.20 (0.31)		
8 years	0.21447 (0.7314)	3.05609 (0.7558)	3.06361	8 years	0.26459 (0.4300)	1.67059 (0.4443)	1.69141
4 years	-4.23365	1.33860	4.61565	4 years	-2.49406	1.45319	2.83654
•	(0.7260)	(0.7415)		·	(0.4268)	(0.4359)	
2 years	0.87433 (0.7175)	-0.26964 (0.7196)	0.91496	2 years	0.35922 (0.4218)	-0.10965 (0.4231)	0.37559
16 months	-0.12402 (0.7066)	0.41533 (0.7272)	0.43346	16 months	-0.05436 (0.4154)	0.265 32 (0.4275)	0.27084
l year	0.57948 (0.7142)	1.64793 (0.7142)	1.74685	l year	0.47921 (0.4199)	0.82169 (0.4199)	0.95122
2 R	0.	7084		a 2	0.	7153	
S.E.E.	3.	3229 (33		S.E.E.	1.9	95 36 (33 d	egrees of freedom)
D.W.	0.	9821	freedom)	D.W.	0.	7933	rreedom)

The numbers in parantheses are the coefficient standard errors.

Corresponding to the Unger Model. -- The annual model developed by Unger contained four endogenous price variables: The average retail price of beef and the average price of "other meat" at retail were analyzed as well as the farm level prices of beef and "other meat". The retail prices were deflated by the consumer price index with base year 1957-59 = 100, and the farm level prices were deflated by the index of prices paid by farmers which includes interest, taxes, and wages, with base year 1957-59 = 100. The "other meat" commodity consists of pork, veal, lamb and mutton, chicken, and turkey. The price aggregates were formed by weighting the retail prices of the individual commodities by the total annual consumption of those commodities, and the farm level prices by the total annual production of the respective commodities. For a more complete description of the process and the exact variables involved, the reader is directed to the original work.

The typical equation in the model as structured by Unger contained 4.5 parameters to be estimated. This led us to form the polynomial trend as a fourth degree polynomial in time and to include two pairs of sine and cosine functions in the trigonometric trend equations (a linear trend variable was added to the model prior to the final analysis to account for long term price movements).

The estimated polynomial trend equations are presented in Tables 23 and 24 and the estimated trigonometric trend equations are in Tables 25 and 26. The relations describing the retail and farm price behavior for beef are in Tables 23 and 25. The relations involving the farm and retail behavior of the prices of other meats are presented in Tables 24 and 26.

Estimated Polynomial Trend Equations

Corresponding to Unger Model

Table 23

Sample Period: 1936-41 and 1949-62, by Years

	Retail Price of		Farm Level Price of	
Exponent	Deflated by Consumer (1957-59 b (¢/lb)	ase)	eflated by Prices Pa (1957-59 ba (\$/Cwt)	ise)
of Time	Coefficient	t-ratio	Coefficient	t-ratio
0	81.23041861	14.3939	19.57937025	7.2911
1	4.96036164	1.5826	0.68988976	0.4626
2	1.04586688	2.1235	0.12154435	0.5186
3	0.06463987	2.3431	0.00359832	0.2741
4	0.00117387	2.3167	-0.00001244	-0.0516
R ²	0.6755		0.4223	
S.E.E.	7.1696 (16 degrees	of reedom)	3.4116 (16 degre	ees of treedom)
D.W.	1.0062		0.7748	

Table 24
Estimated Polynomial Trend Equations
Corresponding to Unger Model

Sample Period: 1936-41 and 1949-62, by Years

Exponent	Deflated by Consumer Price Index (1957-59 base)		Price of Other Meat Animals at Farm Deflated by Prices Paid by Farmers In (1957-59 base) (\$/Cwt)		
of Time	Coefficient	t-ratio	Coefficient	t-ratio	
0	53.293 43890	24.8702	15.82203122	11.9844	
1	1.56279570	1.3131	0.64905361	0.8852	
2	0.73372322	3.9233	0.31178420	2.7060	
3	0.05449259	5.2021	0.02205252	3.4170	
4	0.00111397	5.7898	0.00043926	3.7056	
R ²	0.8685		0.8127		
S.E.E.	2.7224 (16 degrees	of freedom) 1.6773 (16 degree	es of freedom)	
D.W.	1.9575		2.2695		

Table 25

Estimated Trigonometric Trend Equations

Corresponding to Unger Model

Sample Period: 1936-41 and 1949-62, by Years

Annual Average Retail Price of Beef Deflated by Consumer Price Index (1957-59 base) (c/lb)		Annual de Deflated b	Average Pri y Prices Pa 7-59 base)	lce of Beef aid by Farm (\$/Cwt)	at Farm mers Index		
Period		Sine	Amplitude	Period	Cosine	Sine	Amplitude
Intercept	81.91	370		Intercept	20.20	5538	
	(3.75	47)			(1.27	790)	
Time	0.70	1656		Time	0.13	1386	
Time	(0.26			Time	(0.08		
10 years		-5.42237 (3.1270)	5.42246	10 years	-1.98654 (1.1577)	-3.19449 (1.0652)	3.76180
	(3.3750)	(3.12/0)			(1.13//)	(1.0052)	
5 years	0.16478	-1.21075	1.22191	5 years	-1.10591	-0.07925	1.10875
	(3.0007)	(3.1188)		-	(1.0290)	(1.0624)	
R ²	0.4	588		R ²	0.9	5063	
S.E.E.	9.5	624 (15 c	legrees of	S.E.E.	3.2	2574 (15 d	
D.W.	0.7	233	freedom)	D.W.	0.3	7752	freedom)

Numbers in parentheses are coefficient standard errors.

Table 26

Estimated Trigonometric Trend Equations

Corresponding to Unger Model

Sample Period: 1936-41 and 1949-62, by Years

Annual Average Revail Price of Other Meat Annual Average Price of Other Meat at Farm Deflated by C. P. I. (1957-59 base) (c/lb) Deflated by P.P.F.I. (1957-59 base) (\$ Cwt) Period Cosine Sine Amplitude

Intercept	58.86935 (2.4671)	Intercept	17.61304 (0.9594)	
Time	-0.13326 (0.1685)	Time	-0.23978 (0.0655)	
8 years	-4.05316 -0.00795 4. (2.1290) (1.9922)	05317 8 years	-1.73966 0.04381 (0.8279) (0.7747)	1.74021
4 years	-1.21480 -2.88606 3. (2.0249) (2.1281)	13131 4 years	-1.31563 -0.23978 (0.7874) (0.8275)	1.48853
a ²	0.2801	2 R	0.5916	
S.E.E.	6. 5782 (15 degr	ees of S.E.E. reedom)	2.5580 (15 d	egrees of
D.W.	0.6841	D. W.	0.6140	freedom)

Numbers in parentheses are coefficient standard errors.

In terms of the relative degree of explanation during the sample period, the structural equations, excepting those estimated by the limited information single equation method, had the highest degree of explanatory power, followed by the polynomial trend model and then by the trigonometric trend model.

The evaluation of the trend model, as well as econometric and other, forecasts for each set of price variables over a period which includes more nonsample than sample points is presented at a later point in this chapter.

Price Difference Models

The previous two means of generating forecasts are relatively expensive in terms of the resources required to generate the fore-Technical skill is required to formulate and analyze the econometric models used in the first case to generate the forecasts, the required data for both the trend and the econometric models must be collected, and for either case computational skill and/or computing facilities are required to effect the estimation and forecasting pro-This section of the chapter and the next discuss a variety of forecasts (which some might characterize as naive) for which the resource cost is much less than the previous two methods. The forecasting schemes discussed in this section involve price projections which use only the most recent observations from the data series, making certain assumptions regarding the distribution of the differences of the price series. The next section discusses the forecasts which are implies by the prices which prevail in the futures market for the commodity in question, namely beef cattle.

To facilitate the discussion of the difference models the notion of a shift operator will be introduced. The operator to be used in this discussion is a backward shift operator, call it B, which operates in the following fashion: B Y(t) = Y(t-1), $B^{k}Y(t) =$ Y(t-k), $B^{-k}Y(t) = Y(t+k)$, and ABY(t) = AY(t-1), where A is any multiplicative constant. In general terms, all of the algebraic operations that can be performed with scalar constants can be performed on the shift operator. The process of obtaining the k-th difference of a variable Y(t) can be represented quite compactly using the shift operator, as $(1 - B)^k Y(t)$. Seasonal variation can also be represented within the context of a difference model as the product of the basic model and a factor involving the operator raised to the power equal to the period of the seasonal variation: For example, a second difference model involving monthly data and seasonal variation within the year would be represented as $(1 - B)^{2}(1 - B^{12})Y(t) = U(t)$. General weighted average models can be represented as a polynomial in B multiplied by Y(t) which

equals the disturbance: $(a_0 + a_1B + a_2B^2 + ... + a_nB^n)Y(t) = U(t)$. The condition under which the variance of the limiting value of Y is finite, given homoskedastic disturbance terms, is that the largest root of the algebraic polynomial equation $(a_0x^0 + a_1x^{n-1} + ... + a_n) = 0$ be less than unity, a fact that will be touched upon later in a discussion of stability of dynamic systems.

In this thesis, the difference models which were considered to be plausible alternative maintained hypotheses for beef prices were three pure difference models, of first, second and third order, and a hybrid model which represented the product of a first order process and an annual seasonal variation component. When these were compared with the formal models, i.e. the trend approximations and the econometric models, they were used only on a one-step-ahead basis. But in comparing them with the futures market as a forecasting device, the difference models took the algebraic forms: $(1 - B)^{k}Y(t) = U(t)$, in the first difference case; $(1 - B^{k})^{2}Y(t) =$ U(t), in the second difference case; $(1 - B^k)^3 Y(t) = U(t)$, in the third difference case; and $(1 - B^{k})(1 - B^{12})Y(t) = U(t)$, in the hybrid difference model. 2 For these comparisons with the futures market, the lead time involved in the forecast (k) was permitted to vary and took on the values 1, 2, 3, 6, and 8 months. No higher

 $^{^{}f 1}$ The pure difference models are not stable in this sense, as can be noted. See (5).

The explicit forecasting equations are as follows:

Y(t) = Y(t-k) + U(t) in the first difference model, Y(t) = 2 Y(t-k) - Y(t-2k) + U(t) in the second difference model, Y(t) = 3 Y(t-k) - 3 Y(t-2k) + Y(t-3k) + U(t) in the third difference

Y(t) = Y(t-k) + Y(t-12) - Y(t-k-12) + U(t) in the hybrid difference mode1.

values of k were chosen because the futures market did not generate a complete time series for comparison at lead times greater than eight months. 1

The difference equation models were applied to all of the beef price variables in the various econometric models in the one step ahead analysis. The analysis of the effect of lead times on forecasts involved only the beef price series which a) corresponded reasonably with the commodity traded in the futures contract, namely slaughter cattle, and b) were reported on a monthly basis, also corresponding to the time period for which the futures prices were reported.

Futures Market Prices

The futures market is an institution which enables cash market participants to reduce the risk of their enterprises by substituting a certain price in the futures market for an uncertain price in the cash market. As is indicated in Figure 2, producer hedgers would sell futures contracts if the futures price plus their personal risk premium exceeds the expected cash price. Consumer hedgers would buy futures contracts if the futures price minus the risk premium is less than the expected cash price. The buying and selling activities of long and short speculators, respectively, create excess demands and supplies of futures contracts which force the futures price back into the range of the expected cash price plus or minus the risk premium.

The minimum number of cattle futures contracts outstanding during the sample period (1965-1970) was four (each maturing every other month) and the maximum number was nine. The smaller number was the relevant constraint.

Futures Price minus Expected Cash Price

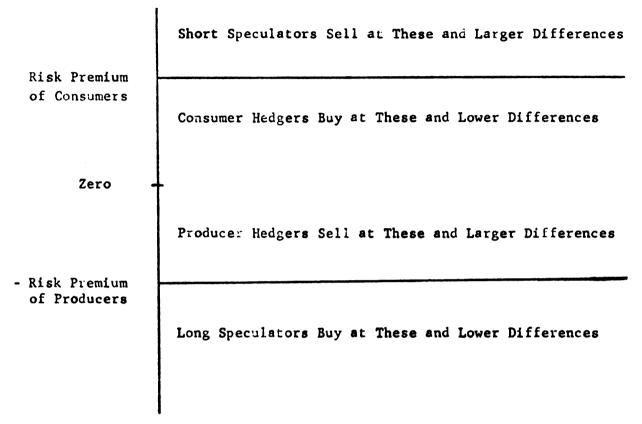


Figure 2: Characterization of Decision Rules Within the Futures Market

As this figure indicates, the equilibrium difference between the expected cash and futures price is determined only to be within a range around zero specified by the risk premium allowed by consumer and producer hedgers. The actual equilibrium is established by the actions of the hedgers, but the equilibrium is stabilized by the action of the speculators in the manner described above.

with the interpretation of the futures price as an aggregate expectation of the cash price (plus or minus the risk premium) which will prevail at a future date (not necessarily the maturity period), we have an easily communicable, simple and, presumably, authoritative source of information concerning prices in the future. These characteristics have already been alluded to, but should be mentioned again. The idea of using the futures market as a source of information on prices is one which is easily communicable, in that most lay individuals can grasp the concept of a contract for future delivery of a specific commodity and the price which is associated with the delivery. Moreover the price quotations for the contracts most directly affecting market participants in an industry, commodity group, or locality are generally quite available. The process of taking advantage of this information or using this as an explicit forecasting device is simple in that all that is required is to

The actual level at which equilibrium is established is dependent on the relative market power of the producer and consumer hedgers. In the absence of knowledge to the contrary, one is tempted to assume equal market power which would give rise to an equilibrium difference at zero, i.e. the futures market would be expected to equal the expected cash price.

The actual terms of the contracts and the mechanism of actual participation in the particular futures market would probably be less well communicated.

locate the quotation for the commodity of interest. The price quotation which is available is authoritative, in that it represents a kind of average of the best judgments of the market participants regarding the price to prevail in or near the maturity month.

That the futures market does not reflect unforeseen events, such as drought, crop failure (domestic and foreign), or institutional changes (e.g. the banning of DES from feeder cattle) is not a fault unique to it as a forecasting device, indeed these events are the reason that virtually all social and economic models are stochastically structured.

The product price whose forecasts are being evaluated in this thesis is that of beef cattle, and there is a live cattle futures contract which is traded at the Chicago Mercantile Exchange, for which data were available at Michigan State University. The three monthly slaughter steer prices which were analyzed in the models

These may be pure judgments or may be based upon the framework of a formal structure (model, if you please) whereby the effects of present and potential circumstances of the market are traced through to their impact on the market price. Since being right is more profitable than being wrong, the ability of a forecaster to survive in the market would be a minimal criterion for accuracy for an individual. Since the futures price represents the aggregate performance of all such individuals it would be expected to be a "stern standard" by which other individual forecasting devices can be measured.

The contract calls for the delivery of 40,000 lbs. of choice live steers, weighing between 1050 and 1150 lbs. and yielding 61 percent carcasses, or between 1151 and 1250 and yielding a dressing percentage of 62 percent. Par delivery for the contract during the period under study (1965 to 1970) took place in Chicago, with delivery allowed at Omaha, Neb., at a discount of \$0.50 per cwt., and at Kansas City, Mo., at a discount of \$1.00 per hundredweight.

The basic data were compiled on a weekly average basis by Keith Holaday Lacy in conjunction with his Master's thesis research (47). This author compiled these into monthly averages.

considered in this thesis are the price of choice 900 - 1100 lb. steers at both Chicago and at Omaha (both delivery points under the contract) and weighted average price of all grades of steers sold out of first hands in Chicago, Omaha, and Sioux City, deflated by the index of wholesale prices with base years 1957-59. The weighted average price posed several interesting problems in its analysis. The first question is how it relates to the other two monthly price The second is what is the effect of the price deflation on the predictability of the series. Finally, since the series is deflated, there is the question of what the appropriate means of deflating the futures price is to make its forecasts in units comparable to those of the realized series. (In response to the last question, the procedure employed was to deflate the futures price by the price level in the month the forecast is being made, effectively assuming that the effects of anticipated subsequent price level changes are negligible.)

As was indicated above, the futures market was evaluated by all of the chosen measures against all of the competing (maintained) hypotheses for the one-step-ahead (one month lead) forecasts, and on the basis of certain selected characteristics of forecast performance with the price difference models for lead periods of one, two, three, six and eight months.

This chapter has discussed both generally and in some detail the four characteristic maintained hypotheses to be used to generate forecasts of beef prices. These maintained hypotheses were that the price movements for beef and to a lesser extent, other meat could best be predicted by 1) an econometric model, 2) an approximation

to the time trend, 3) the current cash market, adjusted to reflect various assumptions concerning the form of the difference model, and 4) the current price of the futures market contract. In the next chapter, these hypotheses will be compared with each other by examining the forecasts generated by each of the models over the 1965 - 1970 time period.

CHAPTER IV

EMPIRICAL EVALUATION OF THE FORECASTING MODELS

The empirical results which are presented in this chapter consist of a discussion of the stability characteristics of the econometric models used in the subsequent analysis, an evaluation of the one-step-ahead forecasts generated by the competing maintained hypotheses for the price variables in each of the econometric models, and finally, an evaluation of the forecasts for differing lead periods of the monthly slaughter steer prices obtained using the futures market price and the case price difference models.

Stability of the Econometric Models

This study of the stability of the models under consideration focuses on the three models which are dynamic, in the sense that lagged endogenous variables are included in their structure. These models were developed by Hayenga and Hacklander, Crom, and Unger. Before the particular empirical results are presented, I will briefly describe the process of determining the dynamic stability (or instability) of a system of difference equations describing, as in this

In his thesis, Myers reached the conclusion that his model was statically stable in the Walrasian sense, since the supply equations were more inelastic than the demand equations (both the cattle and hog supply equations had negative price elasticities. The trierweiler-Hassler model assumed an infinitely inelastic supply of beef and pork on a per capita basis, and hence is stable in the sense of Walras, as well as in the sense of Marshall.

case, a market. (One notes that any econometric model which contains lagged endogenous variables is, in purely mathematical terms, a difference equation system.)

Any purely linear system of difference equations of any order can be represented as a larger dimension linear system of first order, so the system to be discussed is Y(t) = AY(t-1) + BX(t), where Y(t) is an n dimension vector of endogenous variables observed at time t, X(t) is an m dimension vector of exogenous and stochastic variables influencing the system at time t, and A and B are matrices of coefficients with dimensions n X n and n X m, respectively. The general solution to this system of difference equations depends on the initial values of the endogenous variables and on the time path of the exogenous variables in the following manner: $Y(t) = A^t Y(0) + \sum_{k=1}^{t-1} A^k X(t-k)$. This solution will be stable, in the sense that bounded values of the exogenous variables result in bounded values of the endogenous variables, if (and only if) the eigenvalues (characteristic roots) of the A matrix are all less than one in absolute value. The rate of convergence of divergence of the solution depends on the relative magnitude of the largest eigenvalue. To determine if the underlying market is stable or unstable one would need to know the population values of the

The eigenvalues of a square matrix A are those values of r such that the determinantal equation $\det(A-r\,I)=0$ is satisfied. There will be the same number of eigenvalues as the dimension of the matrix. The eigenvectors of a matrix A are those vectors X, each corresponding to one of the eigenvalues, such that Ax=rx. The eigenvectors corresponding to distinct roots are orthogonal, and the vectors can be normalized to length one. If X is the matrix whose columns are the normalized eigenvectors of A and C is the diagonal matrix whose diagonal elements are the eigenvalues of A, then the following relations hold: AX=XC and $A^k=XC^kX^*$.

parameters of the system, and inferences based on the estimated parameters would be subject to sampling variation because of the stochastic nature of the estimated parameters (59, 75). However, if the market under study is apparently stable and the estimated structure is unstable, then this would be an important bit of information in the evaluation of the model.

To determine the eigenvalues of the dynamic models, the determinant of the (A - r I) matrix was directly evaluated for various values of r, because no computer program was available for the calculation of the eigenvalues of a general nonsymmetric matrix. No attempt was made to estimate asymptotic standard errors for these eigenvalues, although an algorithm has been developed (59) which could be applied if the estimated covariance matrix for the structural coefficients were known. For most cases, the conclusions were clear enough without the necessity of formal statistical inference (which would hold only asymptotically in this case, anyway).

The Hayenga-Hacklander Model, as has already been mentioned, is of the form A Y(t) = B Y(t-1) + C X(t) + U(t). The A matrix is of full rank (five) and the B matrix is of rank three (but dimension five). As a consequence there is an eigenvalue of order two at zero, and three other eigenvalues. By the process of numerical approximation and interpolation, these other roots are 0.5240, 0.6719 and 2.6034. By virtue of the root at 2.6034, the system is dynamically unstable without any expectation of oscillation in the path to

Allowing, of course, for the sampling variation to which that inference is subject.

divergence. While this root is subject to a certain amount of sampling variability, the coefficient of variation (the ratio of standard deviation to mean) which would be necessary for there to be any significant probability of stability of the structure is much larger than this writer believes prevails for that variable.

The Crom simulation model involved twenty-five quarterly endogenous variables lagged as many as five periods in the analysis, and five annual variables which were lagged as many as three periods. The quarterly relations contained two nonlinear identities, of the form $\log Y_1 = \log Y_2 + \log Y_3$, which forced me² not to consider the stability of the overall model, much as I would have wanted to. The annual relations were entirely linear in all the variables and this subset of the model was subjected to the eigenvalue test of stability, based on the supposition that the overall model cannot be any more stable than any subsystem within the model.

The annual inventory relations involved five endogenous variables, with the rank of the augmented matrix of coefficients of the lagged endogenous variables being three. This implied that these equations had an eigenvalue of order two at zero. The operating rules Crom imposed upon the system subsequent to estimation give rise to three different sets of coefficients for this subsystem. The

When previously calculated values of the endogenous variables were used as the lagged endogenous variables, rather than the values which actually were observed in the previous period, the path to divergence looked just as this theory projected. As a matter of fact, this divergence motivated the investigation of the eigenvalues of the system as the probable explanation of the phenomenon.

I am not aware of any general theorems which form the basis for determining the stability of nonlinear systems of difference equations.

eigenvalues determined for this subsystem are as follows: For those years prior to June of 1961 when the annual average price of feeder steers was less than or equal to \$27.00, the nonzero eigenvalues were estimated to be -1.5053, 1.2472, and -0.4579. For those years prior to June 1961 when the average price of feeder steers exceeded \$27.00, the only real-valued characteristic root other than zero which was determined in a direct search between 100 and minus 100 was 1.2733. For all values of the feeder price in the years subsequent to June 1961, the eigenvalues were calculated to be -1.5170, 1.2305, and -0.4571.

The large negative eigenvalue estimated in cases one and three above implies that the model if left to operate in an unmodified recursive fashion would tend to generate endogenous variables which oscillate with increasing amplitude as the subsystem diverged. In the second case there would be an unwavering trend towards infinity.

Figure Two of Crom's bulletin illustrates the oscillating divergence of two of the annual inventory variables of this subsystem, in the original run before he imposed any restrictions on the operation of the estimated structure as a simulator of the market. There is also an indication that the quarterly variable representing the number of sows farrowing may have been tending on a path towards infinity with some oscillation imposed over the trend. Both of these observations are consistent with an unstable model. What this would lead us to conclude is that the 147 operating rules which Crom developed for this particular model were designed to, in effect, stabilize a model with an inherently unstable estimated structure (the instability of which Crom was apparently unaware).

The third dynamic model which was analyzed in this thesis was constructed by Unger, and estimated by six different estimation methods. The model contained ten endogenous variables with the matrix of coefficients of lagged endogenous variables being of rank three. For that reason each of the estimated structures has an eigenvalue of order seven at zero. The three nonzero estimated eigenvalues corresponding to each estimate of the system structure are: For the ordinary least squares estimates, 0.95175, 0.425 and 0.000135; for the two stage least squares estimates, 0.96655, 0.505, and -0.0379; for Nagar's unbiased K-class estimates, 0.97469, 0.514, and -0.100; for the three stage least squares estimates, 0.98753, 0.550, and -0.400; for the iterated three stage least squares estimates estimates, 0.98840, 0.550, -0.507; and for the limited information single equation estimates, the roots were calculated to be 1.16635, 0.089, and -36.276.

The interpretation of these estimated eigenvalues is that all except the limited information estimates imply stability in the system, although there is some probability (though likely less than 1/2) that an unstable structure could have generated estimates which are characterized by eigenvalues such as those calculated. The limited information estimates of the structure yielded eigenvalues which imply that, if left to operate by itself, this estimate of the model would generate endogenous variables which would oscillate to infinity. 1

It was apparent that the LISE estimate differed considerably from the other methods of estimation, even prior to the stability analysis. The estimated coefficients of the other methods tended to cluster around common values with the LISE estimates sometimes not

By way of a summary of the results determined in the stability analysis of the dynamic models considered in this tehsis, it was determined that both the model developed by Crom and the one developed by Hayenga and Hacklander are dynamically unstable, and the one developed by Unger is nearly unstable notwithstanding fair degrees of fit during their sample periods. This would seem to indicate that much more work is necessary to describe accurately the dynamics of the beef cattle market.

econometric models in this section is that which is used in the stability theory of linear systems of difference equations having constant coefficients. All of the inferences drawn from this analysis are obviously contingent upon the premises of this theory being fulfilled. In particular, there are two situations in which incorrect inferences of overall market instability may be drawn:

The market forces prevailing may actually be nonlinear, or the model as analyzed may be a part of a larger linear system in which some of the exogenous variables in the current model may become endogenous to the larger model in such a way that a stabilizing feedback loop may be formed in the process. One notes that in either of these circumstances, the model as originally presented would not represent the "true" state of reality.

even agreeing in sign with the others. The "k" values (of the k-class interpretation of LISE) seemed to be consistently larger than their asymptotic value at unity. (It may be noted that this divergence of LISE estimates from other types of simultaneous equations estimates is not an uncommon experience.)

It is also possible that the larger model may become more unstable, even to the extent of converting a stable subsystem into a component of an unstable overall system (53).

To see if the performance of the models which have been shown to be unstable is relatively any different from that of the other models, the next sub-section will describe the predictive performance of each of the econometric models compared to the performance of the trend and difference models, and where applicable, to the futures market.

One-Step-Ahead Performance of Competing Forecasting Models

The alternative maintained hypotheses upon which the price forecasts to be evaluated are based on a) an econometric model, b) four alternative forms of a price difference model, c) the polynomial trend model and d) two forms of the trigonometric trend model, one as estimated, and the other formed by correcting the original estimate by adding the previous period's error.

The Sample Period

Each of the performance measures used in the evaluation process can be construed as a random variable which has a sampling distribution characterized by the maintained hypothesis to which it is applied. As such, it would be conceivable that an "optimal sample size" could be developed corresponding to each of the measures and

The price difference models were not applied to any of the non-beef prices, e.g. hogs, pork, chicken, etc.

One reason these forecasts were corrected in this manner is the extent of the serial correlation apparent in the residuals. Rather than solving explicitly for the estimate of each serial correlation coefficients separately, this correction procedure is equivalent to assuming it to be near one. (Most of the Durbin-Watson statistics were less than 1.0 which is equivalent to serial correlation coefficients greater than 0.50). This correction procedure was also applied to the sets of polynomial estimates which did not immediately diverge.

each of the maintained hypotheses under study. The determination of an "optimal sample size" for all measures simultaneously for all of the maintained hypotheses may also be conceivable once the set of maintained hypotheses is characterized. However, these considerations did not enter formally into the decision regarding the sample size or sample period used for this analysis. The main concerns were data availability and data comparability.

The actual test period chosen was generally the period

January 1965 to December 1970, with exceptions noted in the appendix.

This period is such that it contained some observations from both
the sample period and from outside the sample. It was constrained
at the beginning by the nonexistence of the Live Cattle Futures

Market before November 1964 and at the end by the nonexistence of
the 1971 edition of the Livestock and Meat Statistics, the data from
which formed the backbone of this analysis. This six year period is
slightly more than half the length of the generally accepted cattle
cycle and presented the opportunity of evaluating the forecasts in
periods of both rising and falling prices.

The whole question of data comparability is dealt with at considerable length in the appendix.

Divergence of the Polynomial Trend Models

Of the maintained hypotheses the polynomial trend model was the easiest to evaluate, namely because for all except two cases there was considrable divergence from the realized values within the period of evaluation. The actual definition of divergence which I used in making this judgment is "a model is judged to have diverged

if there is generated an error of at least \$10.00 per hundredweight (106 per lb.) which is sustained until the end of the evaluation period".

For the Hayenga-Hacklander model, divergence of the cattle price polynomial model occurred two months after the sample period and there was divergence of the hog price series six months prior to the end of the sample (perhaps due to the truncation of the coefficients). The trigonometric trend approximation corresponding to the sample used by Hayenga and Hacklander for the steer price diverged one month after the sample period, as was expected from the coefficients of that equation.

The polynomial approximations to the trend in each of the price variables in the Myers model, except the retail price of chicken, diverged from the actual series two months after the close of the sample period. The chicken price in this model diverged after three months.

The Trierweiler-Hassler model was one of two cases where the polynomial trend model was reasonable successful (in the sense of begin less unsuccessful). The polynomial trend approximation to the momthly butcher hog price did not meet the definition of divergence for the entire test period (thirty-six months post sample), although the error at the end of the test period was \$6.00 per hundredweight. The slaughter steer price approximation did not diverge until thirty-one months after the sample, and the approximation to the steer carcass price series diverged twenty months after the sample period. The approximations to the quarterly price series in this model did fit more in line with the pattern of the other results, with the

retail beef price diverging after four quarters and the retail pork price approximation diverging one quarter after the sample period. One hypothesis regarding the longer time required by the monthly approximations to diverge is that the approximating functions are of low degree (they are only cubic equations) and good sample period fits required coefficients such that the time derivatives were close to zero in absolute value.

The trend approximations corresponding to the price variables in the Crom simulation model, with exception of the price of utility cow (nonfed) beef, were all divergent on the first quarterly observation outside the sample period. The divergence of the nonfed beef price occurred three quarters after the close of the sample period.

In the Unger model, the price of beef at retail diverged one year's observation after the sample period and the farm price diverged seven years (i.e. on the last year's observation of the test period) after the sample. The price series for other meat at retail diverged three years post-sample and the farm level price of other meat diverged six years after the close of the sample. Because of the length of time required for the divergence of the farm level prices in this model, I consider this to be the other case where the polynomial trend approximation was less unsuccessful.

Tabulation of Performance Statistics

The general set of performance measures for the polynomial trend models are presented along with those for the other maintained hypotheses only in the cases of monthly variables in the Trierweiler-Hassler Model and for the Unger model. For the other models the

performance criteria corresponding to this hypothesis were not calculated, and hence are not presented.

The difference between the forecasts generated by models indicated by (1) and those denoted by a (2) is that the former constitute the forecasts as actually generated by the estimated equation and the latter forecasts were generated by adding the previous period's error of the basic model to the forecast generated by that particular model in this period. If Y(T) is the actual dependent variable at time T, and the first forecast is Y(1,T) at time T, then the second forecast is generated as Y(2,T) = Y(1,T) + Y(T-1) - Y(1,T-1).

The interpretation of the measures of forecast performance should be fairly straightforward, with all of the measures discussed in Chapter Two above. Because of a possible difference between my usage of the terms and other uses of them, I will repeat the definitions of the Bias measure and the Turning Points measure. The bias is the average difference, accounting for the sign of the difference between the actual price and the forecasted price, so that a model which consistently underestimates the actual price will have a positive bias and one which overestimates the realized price will have a negative bias. The measure of turning point errors might more descriptively be labelled number of incorrect predictions of the direction of change. Since a turning point is said to occur at time t for a series Y when the product $(Y_{t+1} - Y_t)(Y_t - Y_{t-1})$ is negative, the number of turning points in the test period as a whole is equal to the number of "Turning Point Errors" reported for the First Difference model. The larger of the two numbers presented

in the entries along this line is the number of forecasts which went into the analysis (and not the number of changes - which is one less than this number). Probability statements can be made regarding the likelihood that this many or fewer incorrect predictions of change would be generated by a purely random process, such as coin tossing.

The values of the cost derived average loss were calculated based on five alternative assumptions regarding the price of elasticity of supply. The cost derived average loss which is estimated when the supply elasticity is one is precisely the mean square error of the forecasts.

Variables in the Hayenga-Hacklander Model. -- The statistics describing the performance of the alternative maintained hypotheses in forecasting the price variables in the Hayenga and Hacklander model are found in Tables 27 and 28. The beef price forecasts are described in Table 27 and the hog price forecasts in Table 28. Note that the econometric model performs least well of the means compared, and that the best devices appear to be the first and second difference models and the futures market price. The futures market and the second difference model appear to generate nearly the same performance criteria. The corrected trigonometric trend model is better than a no-change model in the case of the hog price (U₂ equal to 0.8266), but slightly worse in the case of the beef price forecasts.

TABLE 27

Forecasts of Choice 900-1100 lb. Steers at Chicago, 1965 to 1970

Mesure of Performance	Hayenga- Hacklander Model	First Difference Model	Second Difference Model	Third Difference Model	Hybrid Difference Model	Putures Market	Trigonometric Trend Model (1)	Trigonomet- ric Trend Model (2)
Cost Derived Loss								
500	9110	•	4000			7000		•
			200.0	500.0	200.0	0000	0.0040	6,000
71.0	0000	0.007	0.0054	0.000	0.007	0.0020	0.0619	0.0037
B = 0.32	0.3003	0.0127	0.0148	0.0351	0.0316	0.0157	0.1032	0.0226
	0.3456	0.0147	0.0171	0.0kg	0.0365	0.0181	0.1190	0.0261
B = 1.00 (M.S.E.)	12.8829	0.5960	0.7019	1.6358	1.4923	0.7267	4.7104	1.0572
Inequality Measures								
	0.8271	1.0013	0.5419	0.5789	0.7787	0.5981	0.7153	0.7239
z.	4.6187	1.0013	1.0792	1.6387	1.5209	1.0922	2.7928	1.3139
Turning Point Errors	27 of 72	21 of 72	15 of 71	22 of 69	20 of 60	17 of 70	36 of 72	27 of 72
Average Absolute Error	3.2184	0.5971	0.6068	0.9007	0.8925	0.6830	1.7127	0.8146
Average Relative Error (Percent)	11.45	2.12	2.14	3.18	3.14	2.42	6.14	2.89
Third Absolute Moment	59.4203	0.8605	1.1538	4.2088	3.4679	1.0667	16.9075	1.9930
Pourth Homent	308.4729	1.6073	2.3389	13.5048	9.5614	2.0511	71.8611	5.0613
Correlation	0.7329	0.9461	9776.0	0.8822	0.8734	0.9293	0.4718	0.9014
Slope	0.8568	93260	0.8550	0.7374	8088	1.0090	0.6142	0.8919
Bias (Average Error)	3.2080	0.0535	-0.0169	0.0147	-0.0672	0.1730	0.1290	0.0073

Table 28

Forecasts of U.S. No. 2-3 Grade, 200 - 220 lb. Barrows and Gilts at Chicago, 1965 to 1970

	Measure of Performance	Hayenga- Hacklander Model		Trigonomet- ric Trend Model (2)
	Cost Derived Loss			
	n = 0.04 n = 0.12 n = 0.32 n = 0.34 n = 1.00 (M.S.E.)	0.0751 0.3042 1.7079 1.9541 65.4714	0.0026 0.0108 0.0633 0.0727 2.5220	0.0015 0.0063 0.0371 0.0426 1.4752
<u>:</u>	Inequality Measures			
	" 1	0.8492	0.4958	0.5199
	u ₂	5.5396	1.0872	0.8266
<u>.</u>	Turning Point Errors	33 of 72	19 of 72	20 of 71
÷	Average Absolute Error	6.4805	1.3078	0.9283
2	Average Relative Error	29.11	5.61	4.14
:	Third Absolute Moment	859.1794	6.1359	3.0132
-	Fourth Moment	13348.6795	17.6494	7.2176
÷	Correlation	0.5588	0.8991	0.9317
	Slope	0.2011	1.0416	0.9325
1	Bias (Average Error)	-1.8292	0.6232	-0.0209

Variables in the Myers Model. -- The performance of the alternative hypotheses in describing the prices studied in Myers! model are presented in Tables 29 throuth 33. The retail and farm level beef prices are presented in Tables 29 and 30, respectively. The forecasts of the retail price of chicken are described in Table 31, and those of the price of pork at retail and hogs at farm level are described in Tables 32 and 33, respectively. His stage I model ("reduced form equations") performed uniformly better than the inverted structural form model. The no-change, or first difference model appeared to be the model to beat, for these variables, and actually was by the corrected trigonometric trend model in the pork and hog price comparisons. The corrected trigonometric approximation model seemed to be the general second choice after the no-change models. After being deflated by the wholesale price index in the month in which the forecast is being made, the futures market forecasted the deflated slaughter steer price to approximately the same degree of accuracy as the current deflated slaughter price of the slaughter price corrected by the change from the preceding month.

Variables in the Trierweiler-Hassler Model. -- The description of the forecasting performance of the hypotheses as regards the dependent variables in the Trierweiler and Hassler model is given in Tables 34 through 38. The monthly carcass price forecasts are in Table 34, the monthly slaughter price forecasts are in the next table and the monthly slaughter hog price forecasts are in Table 36. The forecasts of the quarterly retail beef and pork prices are described in Tables 37 and 38. In the description of the slaughter steer price forecasts, the difference between the equations described

Table 29

Forecasts of Deflated Monthly Retail Price of Beef in Urban Areas, 1965 to 1970

	Mers Structural	Myers Stare I Model	lst	Differer 2nd	Ofference Models 2rd 3rd	Hybrid	Trigonomet- ric Trend Model (1)	Trigonoret- ric Trend Model (2)
Cost Derived Loss								
n = 0.04 n = 0.12	3.78	.0036	.0004	.0006	.0016	\$000°	.0151 .0691	#000°
n = 0.32 n = 0.34	30.89	1218	.0129	.0200	.05/2	7350.	.5210	.0149
n = 1.00 (M.S.E.)	3809.67	10.5333	1.1452	1.7784	4.8335	2.5777	48.3415	1.3233
Inequality Measures								
น้	.9860	.7144	1.0019	.6224	.6747	.7318	.8802	.7511
u ₂	58.0606	3.0547	1.0019	1.2398	2.0320	1.5245	92459	1.0769
Turning Point Error	33 of 72	40 of 72	30 of 71	30 of 70	33 of 69	25 of 59	40 of 72	31 of 71
Average Absolute Error	55.72	2.6209	.7300	.9629	1.5731	1.1046	5.4417	.8537
Average Belative Error (Percent)	76.11	3.57	86.	1.30	2.12	1.50	7.45	1.16
Third Absolute Manent	293731.09	51. 0036	2.9693	4.5478	20.9075	7.3325	527.7480	3.0658
Fourth Earent	> 10,	273.0755	9.8600	13.7728	111.0770	27.5525	6478.6664	9.2091
Correlation	1577	.4623	.8337	.8354	.6788	.7435	0981	.8265
Slope	0114	.2764	.8612	9659.	.4344	.6100	0360	. 8268
Bias (Average Error)	-55.7235	1.5601	0378	0036	0202	1109	4.0124	2272

Table 30

Forecasts of Deflated Price of All Grades of Steers Sold Out of First Hands in Chicago, Omeha, and Slowx City (Weighted Average), 1965 to 1970

	Myers Structural Model	Nyers Stare I Nodel	lst	D1 flarence 2nd	Srd	Hybrid	Futures Market	Trig (1)	Trig (2)
Cost Derived Loss									
n = 0.04	.37			.0006	.0012	2100.	.0006	.0051	
n = 0.32 n = 0.34 n = 1.00 (M.S.E.)	10.68 12.42 663.79	.2450 .2813 9.7573	.0179	.0143 .0165 .6252	.0311 .0358 1.3218	.0300 .0345 .0377	.0149	.1302 .1500 5.7834	.0145 7010. 70109.
Inequality Measures									
Ul	.9751	.8055	1.0018	.5208	.5495	.7539	.5455	8008	.7518
^U 2	34.9325	4.2706	1.0018	1.0566	1.5493	1.5198	1.0511	3.2511	1,0671
Turility Point Error	31 of 72	31 of 72	24 of 71	16 of 70	17 of 69	19 of 59	21 of 69	35 of 72	20 of 71
Average Absolute Error	22.96	2.0586	.5333	.5385	. 8339	.8420	.6293	1.8242	.5913
Average Belative Error (Ferecast)	93.60	10.59	2.32	2.34	3.33	3,39	2.55	7.36	2.35
Third Absolute Monuns	22007.13	41.3333	.7266	0796.	2.9725	2.7027	.7955	24.2944	7605.
Founts Israert	775393.13	190.7061	1.1574	1.7347	8.3559	6.5950	1.2935	118.3380	1.6593
Correlation	9746	0∵;0•	.3647	6003.	.8162	.7585	.8730	.11740	.8671
Sicpe	0092	,0364	2016	.7181	.5737	0259	1.0348	.2774	.7830
bias (Averege Error)	-22.5574	2.2588	.0035	0016	.0326	0612	-,3833	9963	0682

Table 31

Porecasts of Deflated Average Retail Price of Frying Chickens in Urban Areas, 1965 to 1970

	Myers Stru ctural Model	Myers Stage I Model	Trigonametric Tric Trend Model (1)	Triconomet- ric Trend Model (2)
Cost Derived Loss				
n n 0.04	.05 .23 1.54	.0304 .1278 .1777	.0636 .2662 1.6014	.0008 .0033 .0210
n = 0.34 n = 1.00 (M.S.E.)	1.78 91.39	268€. 1006 -4€	1.8432 69. 3447	.0243 1.0839
Inequality Measures				
'n	.9064	.8426	.8853	.6602
u ₂	9.6623	5.9711	8.4167	1.0557
Turning Point Errors	37 of 72	32 of 72	26 of 72	33 of 71
Average Absolute Error	7.90	5.3428	7.6417	.795 ⁴
Average Relative Error (Percent)	23.70	16.22	23.18	2.37
Third Absolute Moment	1229.64	260.4614	691.3653	1.9497
Fourth Mozent	17852.48	2161.9066	7373.0021	4.1705
Correlation	.4236	8767.	.7434	.9068
Slope	.1257	.4781	.3727	6506*
Blas (Average Error)	-6.1257	5.3428	7.6118	.1188

able 32

Porecasts of the Monthly Deflated Retail Price of Pork in Urban Areas, 1965 to 1970

	Myers Structural Model	Myers Stage I Model	Trigonomet- ric lrend Model (1)	Trigonometric Trend Model (2)
Cost Derived Loss				
n = 0.04 n = 0.12 n = 0.32	.49 2.25 17.45	.0267 .1182 .8188	.0080 .0357 .2546	.0009.0042
n = 0.34 n = 1.00 (M.S.E.)	20.60 1802.72	.9559 57. 1531	19,4711	.0349 2.3185
Inequality Measures				
u,	.9675	.8194	.7344	.6032
u ₂	27,1865	101/8°t	2.8254	.9688
Turning Point Errors	34 of 72	21 of 72	27 of 72	22 of 71
Average Absolute Error	36.44	7.0192	3.7351	1.0923
Average Relative Error (Fercent)	62.74	12.04	6.55	1.84
Third Absolute Moment	101652.30	510.6711	120,1863	7.141.7
Fourth Moment	6166450.19	4866.9651	819.9708	27.8651
Correlation	.1741	.8392	6689°	η626•
Slope	.0349	.7262	1.0284	.9678
Bias (Average Error)	-36.3481	7.0192	-3.0046	0608

Table 33

Forecasts of the Eight Market Weighted Average Deflated Price of Barrows and Gilts, 1965 to 1970

	Myers Stru ctural Model	Myers Stage I Model	Trigonomet- ric Trend Model (1)	Trigonametric Trend Model (2)
Cost Derived Loss				
n = 0.04 n = 0.12 n = 0.34 n = 1.00 (M.S.E.)	.36 1.56 10.13 11.75 578.02	.0067 .0275 .1573 .1801 5. 7039	.0047 .0193 .1011. .1261	.0017 .0069 .0398 .0456
Inequality Measures				
U ₂	.9525	.7066	.5976	.6242
U ₂	17.9304	1.7812	1.4936	.9108
Turning Point Errors	38 of 72	28 of 72	27 of 72	17 Jo 42
Average Absolute Error	20.29	2.0131	1.5094	.9455
Average Relative Error (Percent)	105.75	9.89	7.73	69.4
Third Absolute Moment	18777,51	18.6101	14.7148	3.4104
Fourth Moment	655335.22	65.9739	404 2.49	9.5953
Correlation	.0173	.6795	.7595	.9172
Slope	.0041	.7725	1.1378	.9298
Bias (Average Error)	-20.0416	.5738	.0203	0356

Cable 34

Forecasts of Choice 600-700 Lb. Steer Carcasses at Chicago, 1965 to 1970

	Trierweiler Hassler Model	lst	75	æ	Hybrid	Poly (1)	Poly (2)	Trig (1)	1716 (2)
Cost Derived Loss									
n = 0.04 n = 0.12 n = 0.32 n = 1.00 (M.S.E.)	.0059 .0257 .1703 .1979	.0010 .0044 .0291 .0339	.0012 .0052 .0348 .0405	.0026 .0115 .0771 .0898	.0022 .0097 .0651 .0758	.0375 .1674 1.1821 1.3826 88.2519	.0011 .0050 .0340 .0396	.0034 .0150 .1004 .1168	.0009 .0041 .0274 .0319
Incquality Measures									
U ₁	.7425	1.0058	.5527	.5715	.7649	.8889	.7676	.6523	.9047
u ₂	2.3765	1.0058	1.1034	1.6296	1.5115	7.1001	1.1123	1.8918	.9926
Turning Point Error	26 of 72	28 of 71	22 of 70	29 of 69	27 of 59	34 of 72	24 of 71	28 of 72	24 of 7
Average Absolute Error	2.5077	1.0655	1,1067	1.6462	1.4785	6.0836	1.1424	1.7590	1.0353
Average Relative Error (Persent)	5.73	2.48	2.56	3.80	3.38	13.54	2.59	3.92	2.34
Third Absolute Moment	53.0727	4.1075	5.7731	18.7870	15.6390	1750.7384	2.4067	32.6328	4.0078
Fourth Moment	323.4013	n.7136	17.3075	85.7083	72.0725	39360.7214	15.5723	212.9683	11,7866
Correlation	.7147	9դդ6•	.9431	.8822	.8561	.6989	.9284	.7823	.9282
Slope	1.1012	.9337	·8449	.7384	.7611	.2428	.8462	1.1436	.9266
litas (Average Error)	2.0013	.0704	•0030	0126	0472	-4.8333	4129	1.1662	0016

Table 35

Forecasts of the Price of 900-1100 Lb. Choice Steers at Omaha, 1965 to 1970

	Trierveiler Hassler	eller ler	lst	P	Ŗ	Hybrid	Futures	Poly	Poly	Trig	Trig
Cost Derived Loss	, 10 (1)	(2)					Market	3	S)	3	9
n = 0.04 n = 0.12 n = 0.32	.0030 .0126 .0765	.0017 .0073 .0446	.0006 .0027 .0163	.0007	.0015 .0063 .0384	.0014 .0057 .0353	.0006 .0027 .0165	.0182 .0701 .1986	.0007 .0031	.0041	.0006
n = 0.34 n = 1.00 (M.S.E.)	.0881 3.3775	.0514 1.9836	.0187	.0204	.0442 1.7432	20179.1	.0191	.5773 26. 3780	.0219	.1222 4.7540	.0137
Inequality Measures											
U ₁	.7221	.7122	1.0004	.5238	.5432	.7440	.5472	.86.88	.7790	.7153	.9310
n ²	2.0966	1.6068	1.0004	1.0464	1.5153	1.4534	.9978	5.9565	1.0835	2.5287	.9958
Number Fount Error	29 of 72	25 of 72 2	25 of 72	15 of 71	20 of 70	25 of 60	25 of 70	33 of 72 2	23 of 71	28 of 72	23 of 71
Incrare Absolute Error	1.4857	1.0770	.6931	.6754	.9826	.9492	.6735	3.5289	.7 ho4	1.6281	.6903
Wernge Relative Error (Percent)	5.36	3.90	2.52	2.46	3.57	3.43	2.48	12.65	2.70	5.76	2.51
Inited Absolute Moment	9.5404	4.8504	1.0592	1.4369	4.2446	3.9254	1.0837	277.9488	1,3660	18.8176	1.0560
Pourth Moment	31.4723	14.5515	1.8477	3.1073	12.3795	11.1502	1.8181	1.8181 3420.9036	2.5082	88.2400	1.8451
orrelation	.8486	.8640	.9293	.9357	.8770	.8523	.9326	.7193	.9273	.6876	.9260
:lope	1.0790	.9024	.9088	.8217	.7048	.7730	.9780	.2821	₹8•	1.4321	.91
ths (Average Paror)	1.3850	1797.	.0522	0123	710.	0622	3652	-2.5820	221	1.3497	.0240

Table 36

Forecasts of U.S. Nos. 1-3, 220-240 Lb. Barrows and Gilts at Omaha, 1965 to 1970

	T-H Model	Poly (1)	Poly (2)	Trigonomet- ric lrend Model (1)	<pre>Trigonomet- ric lrend Model (2)</pre>
Cost Derived Loss					
n = 0.04 n = 0.12 n = 0.32 n = 0.34 n = 1.00 (M.S.E.)	.0056 .0233 .1354 .1553 5.2103	.0139 .0576 .3366 .3662	.0025 .0102 .0599 .0688 .2.3646	.0196 .0807 .4652 .5331 17,4639	.0021 .0087 .0511 .0536
Increality Measures					
u,	.7398	.7123	.9555	.7359	.7041
u ₂	1.4854	2.3592	.9963	2.7171	.9265
Turning Point Errors	25 of 72	31 of 72	24 of 71	25 of 72	25 of 71
Average Absolute Error	1.8295	3.1686	1.1505	3.6154	1.0706
Average Relative Error (Percent)	8.68	14.33	5.19	15.58	4.80
Third Absolute Moment	19.3886	65.0898	6.3923	100.1663	5.5335
Pourth Moment	86.0843	371.5798	20.0937	657.1828	18.3432
Correlation	.7805	.0267	.8983	.72.10	.9138
Slope	.8295	.0862	.901	1.1869	.903.3
Blas (Average Error)	4513	.3827	0402	3.3880	0246

Table 37

Forecasts of Quarterly Average Retail Price of Beef, 1965 to 1970

	Trierweiler Hassler Model	lst	Differe 2nd	Olfference Model 2nd 3rd	Hybr1d	Trigonomet- ric Trend Model (1)	Triconomet- ric Trend Model (2)
Cost Derived Loss							
n = 0.04 n = 0.12 n = 0.32 n = 1.00 (M.S.E.)	.0123 .0569 .4397 .5189	.0015 .0078 .0604 .0713	.0028 .0128 .1000 .1181	.0075 .0346 .2687 .3173 27. 5952	.0027 .0128 .0996 .1176	.0324 .1495 .1348 .13488	.0015 .0072 .0555 .0656
Inequality Measures							
ď	.8203	1.0129	1699.	.7024	.6334	.8540	.7605
u ₂	4.7442	1.0129	1.3565	2.1694	1.2849	4.3438	7176.
Turning Point Error	8 of 24	7 of 23	9 of 22	7 of 21	8 of 19	8 of 24	6 of 23
Average Absolute Error	6.2553	1.8261	2.3591	3.8000	2.4684	9.0101	1.6754
Average Relative Error (Percent)	7.04	2.00	2.57	4.13	2.68	9.16	1.84
Third Absolute Moment	342.3980	31.5360	59.5518	273.7646	57.2331	1633.8837	27.3482
Fourth Foment	2792.7572	200.2142	376.8210	3161.8068	357.4357	26076.4801	159.4179
Correlation	3062	.9372	.8992	.7963	n468°	. 6441	8446
Slope	1.4985	.9234	.7870	.5968	.8078	2.6957	.8990
Blas (Average Error)	-1.5558	.8174	2045	2381	2579	8.7974	ተከ52°

[able 38]

Forecasts of Quarterly Average Retail Pork Price, 1965 to 1970

Trigonomet- ric Trend Model (2)		.0038 .0171 .270 .1492		.5492	4148°	7 of 23	2.3098	3.15	66.7231	9497.744	.8453	.7645	.5813
Trigonomet- ric Trend Model (1)		.0510 .2298 1.6606 1.94666		.7461	2.9492	8 of 24	10.0945	13.90	2037.9984	33791.9264	.3001	.4358	9.6845
Trierweil er Hassler Model		.0327 1475 1.0512 1.2564		.7868	4.1362	6 of 24	7.6273	10.46	1240.3949	19548.9214	.2561	.3218	6.4483
	Cost Derived Loss	n = 0.04 n = 0.12 n = 0.34 n = 0.34	nality M	v_1	c _n	Turning Point Errors	Average Absolute Error	Average Relative Error (Percent)	Third Absolute Moment	Fourth Fonent	Correlation	Slope	Blas (Average Error)

as (1) and (2) is that in the first cast it is a relation involving the carcass price and time to describe the slaughter price, and the second equation (2) relates the slaughter price to the retail price and the wage rate of food and kindred product workers. 1

In general, the structure model of Trierweiler and Hassler performed better than the uncorrected trend models, both trigonometric and polynomial. The futures market was very similar to the cash market for predicting the slaughter steer price, except for the bias expression which reflected 41.7 cents of the 50 cent per hundred-weight delivery discount at the Omaha market. The corrected trigonometric model performed consistently well for all of the prices in this subset, reflecting at least as much the influence of the nochange (first difference) model as it does that of the trigonometric model.

Variables in the Crom Model. -- The performance of the fore-casting models for Crom's price series is summarized in Tables 39 through 44. The carcass price forecasts corresponding to fed and nonfed beef are in Tables 39 and 40. Forecasts of the slaughter and feeder steer prices are presented in Tables 41 and 42, and the whole-sale and slaughter prices of hogs are presented in Tables 43 and 44.

In terms of the general performance Crom's simulation model was a more accurate forecaster of prices than the uncorrected trend

In the sample period the relation involving time had an R^2 of .951 while the one with the wage rate had an R^2 of .760. This evidence shows that sample fit need not correlate with forecasting ability (or effectiveness). It is heartening to see an example where economics triumphs over trend as an explanation, even it it is only a partial victory.

able 39

Forecasts of the Wholesale Price of Choice Grade Beaf Carcasses (LCL) at New York, Chicago, Los Angeles, San Francisco, and Seattle, June 1964 to June 1970

Second Third Hybrid Trigonomet-Trigonomet- nnce Difference Difference ric Trend ric Trend Model Model (1) Model (2)	0.0063 0.0173 0.0036 0.0046 0.0020 0.0275 0.0760 0.0157 0.0204 0.0089 0.1865 0.5136 0.1068 0.1383 0.0605 0.2173 0.5981 0.1245 0.1611 0.0706 12.1257 33.1331 7.0584 8.9506 4.0004	0.7320 0.7268 0.6061 0.5859 0.6399 1.4529 2.4915 1.1169 1.2928 0.8506	13 10 of 22 10 of 21 6 of 19 5 of 24 12 of 23 2.6505 4.2890 2.0216 2.3209 1.5087	5.60 9.00 4.28 4.86 3.23 70.6812 331.6429 29.7919 45.9402 14.5844	478.5236 3855.1646 136.4098 269.7793 62.6275 0.7107 0.5983 0.7805 0.8794 0.8507	0.5312 0.2940 0.6854 1.3029 0.9608
First Difference Model	0.0028 0.0125 0.0850 0.0991 5.5885	1.0054	11 of 23	3.75 25.2215	0.8037	0.8435
Crom Simulation Model	0.0060 0.0263 0.1788 0.2084	0.5965	7 of 24 2.7313	5.91	334.2807 1	0.5899
Measure of Performence	Cost Derived Loss n = 0.04 n = 0.12 n = 0.32 n = 1.00 (M.S.E.)	Inequality Measures U1	Turning Point Errors Average Absolute Error	Average Relative Error Third Absolute Moment	Fourth Moment 3: Correlation	Slop●

Table 40

Forecasts of the Utility Cow Beef Price at New York City, June 1964 to June 1970

Measure of Performance	Crom Simulation Model	First Difference Model	Second Difference Model	Third Difference Model	Rybrid Difference Model	Trigonomet- ric Trend Model (1)	Trigonomet- ric Trend Model (2)
Cost Derived Loss							
n = 0.04	99000	0.0046	0.0000	0.0198	0.0024	0.0131	0.0087
n = 0.12	0.0291	0.0196	0.0387	0.0858	0.0105	0.0564	0.0374
n = 0.32	0.1835	0.1258	0.2499	0.5640	0.0631	0.3617	0.2407
n = 0.34	0.2122	0.1458	0.2897	0.6549	0.0789	0.4189	0.2789
n - 1.00 (M.S.E.)	9.3290	6.7752	13.8253	33.2196	3.7602	19.3924	13.3389
Inequality Measures							
'n	0.5231	1.0378	0.7253	7669.0	0.4038	0.7539	0.9044
U ₂	1.1987	1.0378	1.4499	2.3442	0.7520	1.7282	1.4405
Turning Point Errors	11 of 24	11 of 23	9 of 22	3 of 21	4 of 19	17 of 24	8 of 23
Average Absolute Error	2.2916	2.0891	2.9564	4.8157	1.6700	3.2922	3.1576
Average Relative Error	6.62	5.73	8.03	12.62	4.45	8.72	8.65
Third Absolute Moment	48.1419	27.0580	77.0437	294.3595	9.9447	160.4893	69.4102
Fourth Moment	277.3095	125.2486 4	483.2757 3	3133.0478	28.7936 1.	1573.1657 4	463.889
Correlation	8/08.0	0.8602	0.7904	0.6754	0.8967	0.6913	0.7308
Nope	0.8059	0.9086	0.5888	0.3555	0.7552	0.9602	0.7253
Blas (Average Error)	-0.0228	0.6752	0.1745	-0.4386	0.0721	2.5947	0.4925

Table 41

Forecasts of the Weighted Average Price of Choice Steers at Twenty Markets, 1964 to 1970

		•					
Measure of Performance	Crom Símulatíon Model	First Difference Model	Second Difference Model	Third Difference Model	Hybr id Diff erence Kodel	Trigonomet- ric Trend Model (1)	Trigonomet- ric Trend Model (2)
Cost Derived Loss							
70°0 = u	0.0043	0.0017	0.0034	0.0091	0.0024	0.0027	0.0013
n - 0.12	0.0183	0.000	0.0142	0.0386	0.0101	0.0115	0.0056
n = 0.32	0.1123	0.0425	0.0867	0.2379	0.0616	0.0697	0.0339
n = 0.34	0.1296	0.0489	0.1000	0.2744	0170	0.0802	0.0391
	5.1677	1.9131		11.1627	2.8079	3.0812	1.5412
Incquality Measures							
'n	0.6178	1.0014	0.7236	0.7330	0.6254	0.5988	0.6658
n ²	1.6789	1.0014	1.4183	2.4859	1.2119	1.2964	0.8988
•							
Turning Point Errors	7 of 24	9 of 23	9 of 22	9 of 21	8 of 19	7 of 24	12 of 23
Average Absolute Error	1.8387	1.0461	1.4995	2.6948	1.3284	1.2955	1.0013
Average Relative Error (Percent)	6.93	3.80	5.44	5.66	4.79	4.70	3.66
Third Absolute Moment	17.5955	4.7722	13.4589	8.4102	7.0632	9.3550	3.0317
Fourth Moment	67.1623	14.3288	52.0668	23.7726	39.5602	32.6714	7.0306
Correlation	0.6895	0.8099	0.7074	0.5792	0.7617	0.8132	0.8352
Slope	0.5589	0.8730	0.5490	0.2925	0.6307	1.0280	0.9980
Bias (Average Error)	-0.9624	0.3313	0.1023	0.0300	-0.1389	1.1526	0.1330

	Forecasts o	f the Price	of Good and	Cnoice 500-8(00 lb. Feeder	Steers at 0	Forecasts of the Price of Good and Choice 500-800 lb. Feeder Steers at Omaha, 1964 to 1970
Measure of Performance	Crom Simulation Model	First Difference Model	Second Difference Model	Third Difference Kodel	Hybrid Difference Model	Trigonomet- ric Trend Nodel (1)	Trigonomet- ric Trend Model (2)
Cost Dervied Loss							
	0.0031 0.0130 0.0790	0.0017	0.0028 0.0119 0.0724	0.0074 0.0312 0.1914	0.0019 0.0082 0.0499	0.0063 0.0266 0.1605	0.0027 0.0114 0.0654
n = 0.34 n = 1.00 (M.S.E.)	0.0910 3.5585	0.0483 1.8381	0.0835 3.3056	0.2 20 <i>7</i> 8. 8950	0.05/5 2.2844	0.1848 7.0392	0.0800 3.1134
Inequality Measures							
u,	0.5934	1.0027	0.6667	9969.0	0.5438	0.7490	0.8000
υ ₂	1.4213	1.0027	1.3154	2.2561	1.1209	1.9990	1.3050
Turning Point Errors	6 of 24	11 of 23	7 of 22	5 of 21	5 of 19	17 of 24	11 of 23
Average Absolute Error	1.4866	1.0196	1.4864	2.2781	1.1942	2.0212	1,3866
Average Relative Error	5.63	3.78	5.49	8.33	4.31	7.28	5.08
Infrd Absolute Moment	10.4564	4.7810	9.3366	43.9063	5.0322	35.2617	8.9913
Fourth Moment	33.5045	15.2455	30.4301	248.0770	11.9722 2	220.6364	29.6681
Correlation	0.8596	9198	0.8506	0.6863	0.8600	0.7199	0.8417
Slope	0.8223	0.9514	0.7288	0.4505	0.7415	0.8545	0.9152
Bias (Average Error)	-0.5849	0.5187	0.0000	9.000.0	-0.0963	1.2781	0.3498

Table 43

Forecasts of the Weighted Average of Wholesale Prices of Individual Pork Products at Chicago, 1964 to 1970

	Measure of Performance	Crom Simulation Model		
	Cost Derived Loss			
	n = 0.04 n = 0.12 n = 0.32 n = 0.34	0.0172 0.0755 0.5103 0.5942	0.0364 0.1600 1.0843 1.2630	0.0040 0.0178 0.1241 0.1450
	n = 1.00 (M.S.E.)	32.8591	70.2505	8.8688
	Inequaltiy Measures			
	v ₁	0.5894	0.7039	0.5053
	v ₂	1.5651	2.2884	0.8092
<u>-</u>	Turning Point Errors	10 of 24	9 of 24	8 of 23
-	Average Absolute Error	4.6641	7.1063	2.3174
<u>-</u>	Average Relative Error	9.44	13.46	4.43
<u>-</u> -	Third Absolute Moment	303.6016	803.9313	44.3613
Ξ.	Fourth Moment	3376.0832 10	140.9440	257.7464
<u>.</u>	Correlation	0.6414	0.5214	0.8654
	Slope	0.4990	0.7423	0.8450
:	Bias (Average Error)	0.1300	6.7336	0.5002

Table 44

Forecasts of the Weighted Average Price of Barrous and Gilts at Eight Markets, 1964 - 1970

=	Measure of Performance	Crom Simulation Model		Trigonomet- ric Trend Model (2)
÷	Cost Derived Loss			
	n = 0.04 n = 0.12 n = 0.32	0.0096 0.0391 0.2213	0.0254 0.1042 0.5921	0.0035 0.0144 0.0847
	n = 0.34 n = 1.00 (M.S.E.)	0.2531 7.8410	0.6777 21.1631	0.0973 3.3920
<u>=</u> .	Inequality Measures			
	u 1	0.5002	0.6643	0.5137
	u ₂	1.2058	1.9809	0.7868
÷	Turning Point Errors	11 of 24	7 of 24	7 of 23
=	Average Absolute Error	2.3079	3.9194	1.5503
=	Average Relative Error	11.24	17.47	7.17
-	Third Absolute Moment	34.2175	136.8809	9.6235
Ξ	Fourth Moment	176.5695	998.6399	32.6358
÷.	Correlation	0.7326	0.6120	0.8623
	Slope .	0.6343	0.8968	0.8412
-	Bias (Average Error)	0.0166	3.6688	0.2336

model performed better than a no-change model for both the pork prices and for two of the four beef prices (the choice steer price and the choice grade carcass price). An observation which is unique in the analysis is that the Hybrid Difference model proved to be the best predictive hypothesis in the case of the price series for utility grade beef, while for all the other prices series considered, this model did quite poorly. Other than this apparent "fluke" in the data, the first difference model appeared to be the most effective here, as elsewhere, of the maintained hypotheses considered, for purposes of generating forecasts.

Variables in the Unger Model. -- The performance of the alternative hypotheses generating forecasts of the price variables created in the Unger thesis is tabulated in Tables 45 through 48, with the retail and farm level beef prices discussed in the first two and the retail and farm level prices of other meat in the last two of this set of tables. This set is interesting, because it allows the comparison of forecasts which differ solely on the basis of means of estimation, having the same structural model, the same data series for both the endogenous and exogenous variables and identical test and sample periods. In this regard, the estimation method whose coefficients generated forecasts with the smallest degree of error, measured both by bias and mean squared error were the two systems methods (three stage least squares and iterated

This may have resulted possibly from some sort of "standard operating procedure" guiding the purchase prices paid by major processors of nonfed beef (e.g. for hamburger, T.V. dinners, and canned meat products) or it may just have been an abberation of the particular data series and sample period.

Table 45

Porecasts of Arnual Average Retail Beef Price, 1964 to 1970

			UNCER Model	Model								
	3 0	SEC.	ž	321.8	રાજ્ઞા	LISE	lst Diff	lst 2nd Difference	žî E	(S)	r E	£ 2
Cost Perived Loss												
n = 0.04 n = 0.12	1.86	.37	.36	8.8	ਜ਼ੇਫ਼	ន់ដ	.0027	.0308	.8876	.0987	.0502	.0036 0366
5.0° = 0	14.71	13. 52	13.18	9.43	9:4	1.76	.0908	.2278	34.8951	3.5020	1.7580	.1232
n = 1.00 (M.S.E.)	1621.16	1479.80	1437.13	1000.33	164.82	169.75	7.9831	19.741	4503.3450	347.3608	168.2962	10.9463
Incountity Measures												
5	8776.	8 .9560	0 .9553	19447	.9139		.8643 1.3787	1.1039	.9725	.9127	.6310	.127
u2	20.5871	1 19.6690	0 19.3834	16.1716	11.0236	6.6617	6.6617 1.3787	2.1803	32.7445	9.1454	4.9085	1.6144
Turning Point Error	3 of 7	7 3 of 7	7 3067	3 0.7	3 of 7	3 06.7	3 of 7 th of 7	3 of 6	3 of 8	3 of 7	3 of 8	L Jo
Average Absolute Error	37.74	36.10	35.56	29.39	19.52	11.23	2.2714	3.8918	\$7.5248	17,1055	11.6148	2.8517
Average Pelative Error (Percent)	51.46	49.22	48.49	40.08	39.92	15.33	3.13	5.33	78.94	23.49	15.98	3.96
Inird Absolute Moment	73796.53	64300.76	61569.31	36798.01	12205.50	2912.31	32.5228	118.3460 4	2912.31 32.5228 118.3460 416993.3660	7983.6994	2710.5146	45.0457
Pourth Moment	3467366.34	2884789.32	2723834.16 1418282.88		339368.11	53472.97 44.4025 769.7184	14,4025	769.7184	> 10	200842.9257 46210.2091 191.8114	1602.01291	191.8114
Correlation	1961.	7951. 7	1961. 7	121.	יוודו	.160	.16043497	.0913	. \$055	.2796	.0874	0263
Slope .	.0139	9, .0146	6 .0148	.0129	.0152	.920	.02672706	.0297	.0212	.0512	.0276	0267
Blas (Average Error)	-37.7419	9 -36.0970	0 -35.5643	3807	-19.5152	-10.7101 4130	14130	4 596	-57.5248	-17.1055	-11.6148	-2.5537

Table 46

Forecasts of Arrual Average Price of Beef Cattle Received by Farmers, 1964 to 1970

			UNCER	Model								
	3	Six	ž	Sis	IXES	LISE	lst Difference	, ,	ŽĴ	2 2 2 3	ĔE	(5)
Cost Derived Loss												
n = 0.04 n = 0.12 n = 0.32		3.55.6	યં. . કે. જે.	3.5.4	801.8	3.52	.0016 .0064 .0361	.0036 .0148 .0824	.0418	.0032	.0109	.003: .0126 .0731
n = 0.34 n = 1.00 (M.S.E.)	168.74	3.48	3.28 129.78	1.66 61.77	% 6.8	1.87 70.34	.0413	.09 ⁴ 1 2.7391	1.2007	2.8674	.3032 10.3661	.0537 2. 6216
Inequality Measures												
'n	.9107	7106.	.8986	. 8549	.7845	.8663	1.2806	.9716	.8544	.6358	.7053	.7011
2°	14.9556	13.5430	13.1163	9.0485	5.7061	9.6559 1.2806	1.2806	2.1506	7.6612	2.2004	3.0945	1.8641
Turning Point Error	2 of 7	. 2 of 7	2 of 7	2 of 7;	2 of 1	2 of 7	1 of 1	3 of 6	2 of 7	3 of 7	2 of 8	3 of 7
Average Absolute Error	21.21	10.92	30.56	7.08	4.17	1.67	.9328	1.3271	6.0434	1.3557	2.7345	1.2220
Average Pelative Error (Percent)	62.39	56.21	ž¥.32	% .5	21.55	38.35	3. 02	6.9	31.05	6.86	14.00	6. 64
Third Absolute Moment	2506.92	1873.59	1706.40	595.73	165.89	696.35	1.8344	6.7933	374.9066	6.7962	45.1337	6.5682
Fourth Foment	38666.29	36367. 96	23327.42	6138.54	1222.23	7214.02	2.8513	18.8401	18.8401 3467.8683	17.1872	207.9721	17.5399
Correlation	.8309	.8368	.8390	.7151	.6189	.8601	.5450	.7430	.8681	.8297	.8076	.2974
Slope	1271.	.1874	0161.	.2049	.2263	.2341	9009	¥612.	.2750	. 3963	.2854	.3425
Blas (Average Error)	-12.1164	-10.9235	-10.5596	-7.0838	A.1661	-7.6664	.2388	9692	-6.8×	-1.2774	-2.1868	9333

Table 47

Forecasts of Annual Average Price of Other Meat at Letail, 1964 to 1970

	OLS	2SLS	Unger Model UNK 3SLS	odel 3SLS	13SLS	LISE	Poly	Poly	Trig	Trig
Cost Derived Loss							3	3	3	3
₹0.0°	0.38	0.42	97.0	0.31	0.18	0.20	0.43	0.07	0.0254	0.0116
n - 0.12	1.71	1.91	5.03	1.41	0.82	0.83	1.97	0.31	0.1135	0.0515
n - 0.32	12.72	14.28	15.21	10.43	50.00	6.45	14.99	2.18	0.800	0.3566
n - 0.34	14.95	16.50	17.90	12.26	7.01	7.57	17.67	2.56	0.9355	0.4163
n - 1.00 (M.S.E.)	1131.97	1290.49	1386.07	915.58	499.98	536.86	1458.63	167.50	59.0991	24.7687
Inequality Measures										
$\mathbf{v_{i}}$	0.9452	0.9433	0.9508	0.9387	0.9168	0.9145	0.9371	0.8791	0.7211	0.8102
U ₂	11.9667	12.771	13.2413	10.7623	7.9530	8.2411	12.8176	4.7951	2.6438	1.6703
Turning Point Errors	2 of 7	2 of 7	2 of 7	1 of 7	2 05 7	2 of 7	3 of 8	2 of 7	4 of 8	t of 1
Average Absolute Error	r 32.24	34.36	35.58	28.71	20.84	22.00	29.78	11.04	6.8994	3.8146
Average Relative Errol (Fereent)	1 63.11	67.22	69.61	56.01	40.62	43.16	59.74	22.10	13.55	7.46
Third Absolute Bonent	42054	51444	57341	315 12	13127	13969	85225	2668	545.61	183.02
Fourth lonent	1625946	2132745	2463146	1143383	364063	375479	5370054	43410	5203.11	1450.01
Correlation	0.3635	0.3757	0.3301	0.5229	0.5561	0.3247	-0.5480	-0.6797	99570	0.1540
Slope	0.0903	0.0856	0.0831	0.1252	0.1534	0.1078	-0.0672	-0.4284	0.3189	0.0918
Bins (Average Euror) -32.2359	-32.2359	-34.3551	-35.5823	-28.7061	-20.8397	-22.0016	-29.7816 -10.9995	-10.9995	-6.8994	-0.2846

able 48

Forecasts of Annual Average Price of Other Meat Received by Farmers, 1964 to 1970

			ນຄຸດ	Unger Model			Poly	Poly	Trie	Tris
	OLS	2SLS	UNK	3SLS	13SLS	LISE	Ξ	(2)	3	(2)
Cost Derived Loss										
70.0	51.0	0.17	97	91 0	0	37' 76	9	č	0,00	6
	3	0.71	0.75	0.57	0.38	123.55	0.79	0.15	0.0202	0.0336
n · 0.32	3.62	4.22	4.49	3.37	1.91	1201.32	4.85	0.87	0.1107	0.1834
n • 0.34	01,.4	4.35	5.17	3.38	2.20	1452.02	5.60	0.99	0.1203	0.2091
n - 1.00 (M.S.E.)	160.58	179.65	193.05	140.68	75.36	294593.63	229.31	31.24	3.5137	5.7073
Inequality Messures										
เก	0.9072	0.9124	0.9156	0.9000	0.8623	1.0138	0.9127	0.8705	0.4522	0.7101
Ľ2	7.4618	7.8333	8.1157	6.9279	5.0708	317.0665	8.8452	3.3970	1.1674	1.5954
Turning Point Errors	2 of 7	2 of 7	2 of 7	1 of 7	2 of 7	2 of 7	3 of 8	2 of 7	4 of 8	4 of 7
Average Absolute Error 12.05	: 12.05	12.74	13.20	11.15	7.94	526.50	11.49	76.95	.1.5137	2.2760
Average Relative Error 74,32 (Percent)	: 74.32	80.65	83.56	70.41	50.18	3320.22	74.89	31.84	9.81	14.40
Third Absolute Noment	2305	2732	3037	1950	803	> 10	5401	223	9.4151	15.6689
Fourth Moment	34697	43632	50183	28787	9169	> 10 ⁷	137654	1699	27.5334	46.5308
Correlation	0.2241	0.2305	0.2324	0.3307	0.3632	0.0936	-0.3784	-0.6310	0.4632	-0.1466
Slove	0.0737	0.0709	0.0691	0.1019	0.1276	0.0010	-0.0538	-0.3695	0.3077	-0.1083
Blas (Average Euror)-12.0453	12.0453	-12.7358	-13.2015	-11.1495	-7.9436	-526.4995	-11.4873	-4.5339	-0.7116	0.2715

three stage least squares). However, ranking the methods on the basis of the correlation between the forecast and the realized price for each of the four variables did not yield a consensus, because the ranking on this measure for the beef price variables is nearly perfectly correlated in a negative sense with the ranking for the other meat price variables.

In comparison with the trend models, the best estimates generated by the econometric model appear better than the polynomial trend model and worse than the trigonometric trend model. Correcting the trend models to reflect the error of the previous year, had the effect of reducing the mean square error at the expense of a lower correlation of forecast with realization.

Among the forecasting methods applied to the variables used in Unger's thesis, there did not appear to be any method which proved to be significantly better than an extrapolation calling for no change in the dependent variable. One will recall that this observation has characterized the forecasts generated by all the different sets of models, and as such, constitutes a real challenge to price analysis and other researchers concerned with explaining this subsector of the agricultural economy.

Effect of Lead Period on Forecasts Based on Futures Market Price and Price Difference Models

We have already seen the performance of the different means of generating price forecasts for one month into the future. In considering forecasts with different lead periods between the forecast and the realization the comparisons which will be presented

involve only monthly data, and are generated by the futures market price and the cash market price difference models. Although there are four separate price difference models which were considered, the comparison is effectively between the first difference cash price model and the futures market forecast, because of a uniform domination of the performance of the other difference models by the first difference model (i.e. which states that the current price is expected to prevail in the forecast period). The different lead periods which are considered in this analysis are one, two, three, six and eight months from the forecast date.

Tables 49, 50 and 51 present this analysis for the price of choice 900-1100 lb. slaughter steers in Chicago, and Omaha, and the weighted average price of all grades of steers sold in Chicago, Omaha and Sioux City, deflated by the wholesale price index with 1957-59 as base respectively.

Some of the observations which seem apparent from these tables are: First, forecasts get worse the longer the period between the forecast and the realization. Second, for all lead periods the nondeflated cash prices are more easily forecast (as indicated by the correlation) than are the deflated prices, but are subject to more variation (as indicated by the mean square error). Third, for short term forecasts (i.e. for less than three months into the future) the futures price and the current cash price seem to be virtually equivalent means of forecasting the nondeflated prices. For forecasts more distant than this, it appears that the current cash price is somewhat a better device than the futures price.

Note that the futures market price is virtually uncorrelated with

Table 49

Price Forecasts For Choice 900 - 1100 lb. Steers at Chicago 1965 - 1970

Performance of	First	Second	Third	Hybrid	Futures
Forecasts with Lead			Difference	•	Market
Period Equal to K	Nodel	l'odel	Hodel	Model	Nodel
K = 1					
Mean Square Liror	0.5960	0.7019	1.6358	1.4923	0.7267
Dias(Avrunge Inner)	0.0535	-0.0169	0.0147	-0.0672	0.1730
Average Absolute Error	0.5971	0.6063	0.9007	0.8925	0.6830
Correlation	0.9461 21 of 72	0.9444 15 of 71	0.8822 22 of 70	0.8734 20 of 60	0.9293 17 of 70
Turning Point Errors	21 01 72	15 61 71	22 61 70	20 01 00	17 01 70
K = 2					
Mean Square Error	1.6914	3.1199	8.3553	4.0728	1.9176
Eias (Averene Error)	0.1158	-0.0712	-0. 0796	-0.1188	0.3379
Average Absolute Error	1.0265	1.3480	2.2255	1.562	1.1211
Correlation	0.8469	0.7895	0.3.36	0.7003	0.8028
Turning Point Errors	31 of 71	32 of 69	29 of 67	30 of 59	24 of 69
K = 3					
Non Savana Empa	2.7341	6.3732	19.4623	6.1004	3.2648
Nean Square Error Bias (Average Error)	0.2020	-0.1663	-0. 0300	-0.1678	0.5025
Average Absolute Error	1.2500	1.8925	3.3503	1.8550	1.4341
Correlation	0.7513	0.6177	0.4583	0.5923	≎.6624
Tarning Point Errors	40 of 70	36 of 67	33 of 64	32 of 58	30 of 69
K = 6					
Mean Square Error	4.3350	11.4760	38.7134	8.0754	6.8758
Bias (Average Error)	0.4501	-0.2969	-0.1329	-0.3020	0.7219
Average Absolute Error	1.6827	2.4943	4.4060	2.2504	2.1638
Correlation	0.6065	0.4279	0.2461	0.5413	0.2601
Turning Point Errors	34 of 67	25 of 61	26 of 55	28 of 55	32 of 67
K = 8					
Mean Square Error	4.7284	11.7937	37.6170	9.0802	8.0653
Bias (Average Error)	0.5868	-0.2474	0.6982	-0.3881	0.7524
Average Absolute Error	1.7613	2.7288	4.8292	2.3836	2.3053
Correlation	0.5800	0.4240	0.3054	0.5321	0.0959
Turning Point Errors	34 of 65	33 of 57	27 of 49	27 of 53	35 of 65

Table 50

Pric: Torecasts For Choice 900 - 1100 lb. Steers at Omaha
1965 - 1970

Performance of	First	Second	Third	Hybrid	Futures
Forecasts with Lead	Difference	Difference	Difference	Difference	Market
Period Equal to K	Nodel	Nodel	Model	Nodel	Model
K = 1					
Mira for well out Eira (Amen Arror) Action (Amen Arror) Condition of Impors	0.7473	0.8259	1.7432	1.6446	0.7558
	0.0522	-0.0123	0.0177	-0.0622	-0.3652
	0.0331	0.6734	0.9026	0.9492	0.6735
	0.9_13	0.9217	0.0770	0.8523	0.9326
	25 of 72	15 of 71	20 of 70	25 of 60	25 of 70
K = 2					
Mona County Turor	2.1915	4.1807	11.2001	4.5523	1.6924
rias (.vere + Error)	0.1125	-0.0555	-0.0767	-0.1168	-0.3766
Awarene Missing Error	1.1644	1.6187	2.7115	1.6042	1.0624
Connelacies	0.7918	0.7320	0.5948	0.6533	0.8198
Turning Pelan Prrovs	41 of 71	38 of 69	37 of 67	34 of 59	30 of 69
K = 3					
Mean Square Peror	3.5494	8.4450	25.0589	6.5781	2.6993
bias (Awareja Error)	0.1950	-0.2004	-0.1164	-0.1836	-J.2120
Avareja di Linta Error	1.4296	2.2437	3.9342	1.9053	1.3001
Carrelation	0.5231	0.5163	0.4136	0.5450	0.6852
Turning Point Errors	44 of 70	39 of 67	34 of 64	32 of 59	36 of 69
K = 6					
Mean Square Error	5.2995	14.9822	51.4689	7.9138	5.9349
Bies (Average Error)	0.4596	-0.3333	-0.0713	-0.3236	0.0065
Average Absolute Error	1.5258	2.9664	5.4640	2.2029	2.0253
Correlation	0024	0.2544	0.0367	0.5059	0.2735
Turning Point Errors	30 of 67	28 of 61	25 of 55	31 of 55	32 of 67
K = 8.					
Mean Equare Error	5.1487	12.5148	38.4921	8.3854	7.1843
Bias (Average Liver)	0.5843	-0.2298	0.6873	-0.4164	0.0227
Average Absolute Error	1.7705	2.6975	4.5722	2.2225	2.1959
Correlation	0.5073	0.3539	0.2395	0.4992	0.0911
Turning Point Errors	36 of 65	29 of 57	27 of 49	22 of 53	33 of 65

Table 51

Forecasts of Weighted Average Deflated Price of All Grades of Slaughter Steers at Three Markets 1965 - 1970

	First	Second	Third	Hybrid	Futures
	Difference	Difference	Difference	Difference	Market
	Model	Model	Model	Model	Model
K - 1					
Mean Square Error Bias (Average Error) Average Absolute Error Correlation Turning Point Errors	0.5555	0.6252	1.3218	1.2977	0.6188
	0.0035	-0.0016	0.0026	-0.0612	-0.3833
	0.5838	0.5885	0.8389	0.8490	0.6293
	0.8647	0.8990	0.8162	0.7585	0.8730
	24 of 71	16 of 70	17 of 69	19 of 59	21 of 70
K = 2					
Mean Square Error	1.6176	3.0691	8.2805	3.6523	1.3240
Bias (Average Error)	0.0194	-0.0735	-0.0768	-0.1350	-0.4443
Average Absolute Error	0.9944	1.3746	2.2729	1.4284	0.9401
Correlation	0.5991	0.6104	0.5272	0.4754	0.6515
Turning Point Errors	41 of 70	34 of 68	35 of 66	32 of 58	30 of 69
K = 3					
Mean Square Error	2.5968	6.0913	18.0127	5.3915	2.0793
Bias (Average Error)	0.0509	-0.2081	-0.0040	-0.2068	-0.3492
Average Absolute Error	1.1967	1.8898	3.2897	1.6780	1.1378
Correlation	0.3535	0.3552	0.2983	0.3347	0.3599
Turning Point Errors	44 of 69	38 of 66	32 of 63	33 of 57	34 of 69
к = 6					
Mean Square Error	3.7007	10.4644	35.6286	6.8115	4.5601
Bias (Average Error)	0.0897	-0.2424	0.0200	-0.2443	-0.3105
Average Absolute Error	1.5128	2.5097	4.5836	2.0251	1.7805
Correlation	0.1000	0.0966	-0.0594	0.2650	-0.3961
Turning Point Errors	35 of 66	29 of 60	26 of 54	31 of 54	38 of 67
K = 8					
Mean Square Error	3.6479	9.9929	31.8110	7.3094	5.3916
Bias (Average Error)	0.0960	-0.1881	0.7214	-0.3382	-0.4135
Average Absolute Error	1.4949	2.3865	4.2720	2.0775	1.9070
Correlation	0.1321	0.1423	0.2039	0.1971	-0.5802
Turning Point Errors	29 of 64	27 of 56	21 of 48	25 of 52	34 of 65

the cash price eight months away and only slightly correlated with the price six months away.

An analysis of the average errors of the first difference and the futures market models reveals that the contract prices average about twenty cents per hundredweight below the Chicago cash price and about four cents below the Omaha price adjusted for the delivery allowance (fifty cents per hundredweight) at nearly any point in time. The difference in forecasting accuracy between the cash and futures prices suggests that there may exist an opportunity for speculation on distant contracts to improve the forecasting performance of the market. It remains to be seen whether a strategy of operating in the distant futures market as if the current cash price is the price at maturity would be profitable enough to attract sufficient speculators to potentially affect its predictive performance.

Summary

As a short summary of the empirical findings of this chapter, it has been observed that the econometric models did not perform as well as some of the other forecasting devices which were considered, indeed there were cases where the trigonometric trend models performed much better than the structural models. The most general observation on the forecasting performance of the alternative maintained hypotheses is that the low cost (in the sense of private costs) methods, particularly the no-change (first difference) model and the futures market price, proved to be devices at least as good as the more sophisticated models for purposes of price forecasting. If

these models are at all representative of the set of all econometric models of beef prices this might be taken as an indicator of disequilibrium in the price research market, since one would expect that the marginal benefits attributable to a model should tend to approach the marginal cost of the model. With negative benefits and positive costs, the situation does not appear as if it should be permitted to remain in its current state.

By viewing the rankings of the different devices based on the different measures of performance, the inconsistencies and similarities of the different measures with each other become apparent. For example, the rankings of the cost derived loss function, mean square error and Theil's U₂ inequality measure are identical, while the separate rankings based on the correlation, bias and mean squared error are not necessarily the same.

In the chapter which follows a brief summary of the research will be presented together with the major conclusions of the study and recommendations for further research.

CHAPTER V

SUMMARY AND CONCLUSTONS

This thesis has two separate orientations within its organization. Following an introductory chapter, the second chapter of the thesis presented a theoretical analysis of the forecasting process, as it affects the measures which are used to evaluate forecasting performance. The fourth chapter applies the measures which are developed and discussed in the second chapter to evaluate the alternative forecasting devices for prices affecting the beef industry which were described in Chapter III. The main body of this summary and conclusions chapter will likewise be organized around this theoretical - empirical dichotomy. At the end of this discussion, I will recommend further work which can build upon this analysis and would improve upon the state of the empirical arts in beef price models.

Theoretical

The theoretical chapter begins by examining the process of forecasting in general, and price forecasting in particular, from the viewpoint of decision theory. It is observed that the forecaster is making a statement (taking an action) about the price to prevail (in the face of uncertain states of nature) and must face the consequences of his error (incur a loss when the action is not appropriate to the state of nature). Since the forecasting device

determines the action taken, and the realized prices are what they are, the process of forecast evaluation is one which must focus on the appropriate function to represent the losses incurred when the forecast is p and the realization is r. In this thesis it was assumed that the appropriate measure of loss from forecasting error is the difference between the maximum possible profits accruable to a firm under the realized price and the actual profits realized by the firm when it determines its output assuming the forecast would be realized.

Assuming the firm which is using the forecast can be represented by a homogeneous production function, that input prices are predetermined and that only the output price is being forecast, I was able to derive the function which measures the loss (in the sense referred to above) incurred by the firm as a result of incorrect forecasts. This loss function is given by the expression $(r^{1+n} - (1+n) r p^n + n p^{1+n}) (n/K)^n (1+n)^{-1-n}$ where r and p are the realized and forecasted prices, n is the elasticity of the firm's short run supply curve (related to the production homogeneity (h) by n = h/(1-h)), and K is the constant of proportionality of the total variable cost function, $c = K q^{1/h}$, depending upon the input prices and the production parameters.

It was shown that if the supply elasticity were equal to one, i.e. the production homogeneity were one-half, this loss function would be quadratic. Further, it was shown that the estimator, namely the posterior expected price, which minimized the expected squared error also mimimized the cost derived loss function. By factoring the cost derived loss function, a particular type of

"squared error" term was one of the factors of the expression. All of these results led one to suspect that there should be a high degree of correspondence between the rankings of the forecasts by the cost derived loss function and the mean squared error criterion. In the empirical chapter, an examination of the tabulated performance measures showed than there were no inconsistencies between the two rankings.

The one area where the "robustness" of the least squares type of criteria is not as evident, without substantial assumptions, is in the determination of the relative gains from using one estimator over another when the costs of the two are unequal. In this case, one would have to know the supply elasticity and hence calculate the cost derived loss, to balance the additional costs of one estimator relative to another with the additional gain in performance provided by the first estimator over the second. Thus, there is the necessity of obtaining technological information about an industry, e.g. production homogeneities or supply elasticities, before one can recommend an appropriate forecasting device for prices in that industry.

With the relation of mean squared error to the cost derived loss function thus established, the analysis in the theoretical chapter sought to relate other common measures of forecasting error to the mean squared error criterion. It was noted that the mean squared error could be partitioned into expressions which involve the forecasting bias, the slope of the relation of forecasts to realizations and the degree of fit of that relationship. This partition indicates that, certeris paribus, anything which reduces

the bias, makes the slope closer to plus one, or increases the correlation between the forecast and the realization will decrease the mean squared error. Since the ceteris paribus condition is not expected to hold in all cases it is expected that these measures of performance would rank the forecasting devices somewhat differently than the mean squared error criterion. In the empirical chapter, evidence substantiating this expectation is found. See also Table 53 of this chapter for a summary of that evidence.

The inequality coefficients, U₁ and U₂, developed by Theil were motivated by the idea of a quadratic loss function and are functions of the mean squared error as was shown in the theoretical chapter. Because U₁ depends on the forecasted changes as well as the forecasting errors and can therefore take values independent of the mean square error, Theil concluded that U₂ was a preferable measure of forecasting performance. Besides, the U₂ statistic provides both a relative and an absolute measure of performance, since the denominator is the mean squared error of the successive differences. Consequently, values of U₂ greater than one indicate that the forecast under study was no better than the last period's price as a forecaster.

A similar threshold for interpretation of U_1 was derived in the theoretical chapter which indicates that values of U_1 less than the square root of two divided by two are associated with forecasts which are positively correlated with the realized prices. That this threshold is related to, but not identical with, the threshold of U_2 at one is demonstrated in Table 52 which tabulates the joint frequency of occurrence of U_1 and U_2 as calculated in

Table 52

Joint Frequency of Occurrence of $\mathbf{U_1}$ and $\mathbf{U_2}$

	v ₂ < 1.0	1.0 € U ₂ < 1.3	1.3 ≤ U ₂	Tot al
U ₁ < 0.5	1	2	0	3
0.5 4 U ₁ < 0.6	5	11	8	24
0.6 € U ₁ < 0.7	4	5	9	18
0.7 4 U ₁ 4 0.8	2	4	34	40
0.8 \ U ₁ < 0.9	0	0	23	23
0.9 ₹ U ₁	3	11	31	45
Total	15	32	105	153

the evaluations of the empirical chapter. Apparently, the difference between the two threshold points is that the previous period's observation is generally quite highly correlated with the current observation, which would mean that a much smaller value of U₁ would be necessary to be equivalent to the U₂ threshold.

Of the other measures of forecasting performance, the moment measures are most closely related to each other. These include the mean squared error, the average absolute error, the third absolute moment, and the fourth moment measures. Of the same form, but not directly comparable to the others, is the average relative error. The moment measures differ from each other in terms of the weight that they each give to outlying points. Consequently, one would believe that adjacent sample moment measures would rank the forecasting hypothesis similarly. The evidence obtained in the empirical chapter supports this belief except possibly in the case of the comparison of mean square error with the average absolute error.

Table 53 shows the number of times that each of the indicated pairs of performance measures identically ranked each element of the set of forecasting devices. Also shown in this table is the number of times the same elements received the same ranks plus the number of times that there was only one error in the ranking, i.e. when one pair of ranks was inverted. Since the probability of obtaining sixteen or more successes in twenty-two Bernoulli trials with equally likely outcomes is approximately .0274, using the Central Limit Theorem, this was taken to be the cutting point for

The chi square statistic corresponding to the null hypothesis of independence is approximately 41.6. The .9995 point for the chi square distribution with 10 degrees of freedom is 31.4.

Table 53

Number of Coincident Rankings of Forecasting Devices (of 22 Possible)

U_ Inequality Measure	16						
Average Absolute Error	12	13					
Average Relative Error	11	8	19				
Third Absolute Moment	18	13	11	10			
Fourth Moment	13	10	8	8	17		
Correlation	5	7	6	6	5	5	
Turning Point Errors	1	1.	1	1	1	1	1
	MSE	\mathtt{U}_{2}	AAE	ARE	3AM	4M	ρ

Number of Coincident Rankings Allowing the Inversion of One Pair of Ranks

	MSE	v_2	AAE	ARE	3AM	4M	ρ
Turning Point Errors	4	3	4	4	4	4	3
Correlation	11	12	14	12	11	9	
Fourth Moment	19	16	14	15	21		
Third Absolute Moment	20	19	17	17			
Average Relative Error	18	14	22				
Average Absolute Error	19	18					
U ₂ Inequality Measure	22						

assessing agreement among the rankings in the top portion of the table. With this criterion for agreement, it is apparent that ranking by mean squared error is substantially the same as ranking by the U2 inequality measure and by the third absolute moment and that ranking by the third absolute moment is substantially the same as ranking by the fourth moment (although the rankings relationship is not transitive). Further, we observe that the average absolute error resulted in rankings which matched the rankings of the average relative error. Allowing for a single error, as was done in the lower portion of the table, does not affect the general conclusions of the analysis, although the critical region is changed. Note that the rankings based on correlation of the forecast with the realization are not significantly related in this sense with the rankings which resulted from the error moments. 1 Further note that there is no relation of the turning point rankings with the rankings using the other measures, which is a rather surprising result.

With this analysis of the different performance criteria completed, three measures were used to assess the performance of the alternative models for forecasting beef prices: mean squared error, the $\rm U_2$ inequality measure, and the correlation of the forecast with the realization.

I believe that defining the significance of the relationship as I did is a stronger measure of relationship than some sort of aggregate rank correlation measure. In my sense, there has to be a perfect rank correlation of plus one before a success is determined to have occurred in the Bernoulli trial. I have not been able to prove or disprove my belief, however.

Empirical

In the empirical analysis of the forecasting models three subsets of work were done: First, the stability characteristics of the econometric models were studied. Then the alternative models for the forecasts on a one-step-ahead basis were examined. Finally, the effectiveness of the low-cost forecasting models, i.e., the futures market and the price difference models, in correctly forecasting the prices up to eight months ahead was studied. The results of these analyses follow.

The stability analysis showed that the two static models, namely of Myers and Trierweiler and Hassler, were both stable in the sense of Walras. This means that as long as prices adjust to changes in excess demand or supply, the model is stable. Since the implicitly assumed supply function of the Trierweiler-Hassler is independent of price, this model is also stable in the sense of Marshall, that is, equilibrium can be attained by quantity adjustments to situations of excess supply and excess demand. Because the supply functions in the Myers model are negatively sloped with respect to price, this model is not stable in the sense of Marshall.

The stability theory for the dynamic models is based in the stability theory of linear difference equations, namely the model is stable if the absolute value (or modulus) of the largest characteristic root of the system is less than one. If this dominant root is negative and less than -1.0, the endogenous variables in the system will oscillate with increasing amplitude, and if positive and greater than 1.0, the endogenous variables will follow a direct path toward either of the infinities.

The results of the stability analysis of the dynamic models showed that all the dynamic models were either unstable or exhibited tendencies towards instability. The monthly Hayenga-Hacklander model had its dominant root at 2.6, which meant that recursively operating this model would have resulted in direct divergence of the calculated endogenous variables.

The Crom quarterly model included two nonlinear identities which prevented the analysis of the stability of the overall model. Operating with the assumption that the overall model cannot be any more stable than any subset of it, I studied the stability characteristics of the annual inventory subsystem. The dominant root of this system was found to be approximately -1.5, with another root at 1.25. These roots would cause the solutions to the system to oscillate with increasing amplitude over time.

The annual model developed by Unger was determined to be stable, but the calculated eigenvalues were close to the critical value of one. In cases such as these, estimates of the variances of these roots would have been helpful in making probability statements regarding the likelihood of an unstable structure given these estimated eigenvalues (type II error). The estimate of this model obtained by the limited information single equation estimator was in fact unstable with roots at -36.3 and 1.17. The other five estimates of the model gave rise to estimated dominant roots of between 0.951 and 0.988. Because the limited information estimate of the model gave coefficients which were virtually unrelated to the estimates obtained by the other methods, less faith is placed in the "clear indication" of instability of the model based on this

estimate than in the marginal indications of stability of the model provided by the estimates of the model which were obtained by the other means.

The concluding observations regarding the stability analysis which were performed in this thesis should include at least two points. First, it appears that the beef cattle subsector of the economy is either at the brink of instability or the models which have been studied in this thesis in some way misrepresent behavior in it, especially as regards the stability characteristics in the industry. Second, it would appear that at least in the case of Crom model, there was a degree of recognition that the model by itself was not representing the recorded history, without knowing that a major part of the problem was the instability of estimated structure of the model. The 147 operating rules which he subsequently imposed upon the model constitute, at least partly, an attempt to impose stability on a structure of estimated coefficients which is, itself, unstable. Perhaps a better allocation of resources would have been to determine the cause of the model instability, than to attempt to "coerce" stability out of an unwilling structure.

In the assessment of the different maintained hypotheses as bases for price forecasting, the underlying judgment was that the returns from the model in terms of its performance should be roughly proportional to the costs² (at least in the marginal sense) if there

The basis for this judgement is this writer's belief in the inherent stability of the beef industry.

The information (either in amount or in value) obtained from a forecasting device should be related to information put into that device (again, either in total quantity or in terms of cost).

is an approximation to equilibrium in the market for price forecasts. In this sense, econometric models were viewed as high cost, but potentially high valued forecasting devices. Trend models, both polynomial and trigonometric, were seen as lower cost substitutes for and approximations to the solutions of the econometric models. These were compared with models which in this continuum are lowest cost, namely price difference models and futures market prices. The expectation of model performance was roughly in that order, that the econometric models would perform better over the test period than the trend models which were expected to perform better than the simple models. It was expected that the futures market would be a better forecaster than the price difference models, and presumably than the other devices as well, because the participants in the futures market could use these methods as the basis for their expectation of price in or near the maturity month for the contract.

The results of the evaluations of the alternative forecasting models were surprising, in that not only were the expectations not fulfilled, there was a negative rank correlation between the expectations and the conclusions on the order of -0.3. In particular the results showed that the polynomial trends diverged to a degree that evaluation of the descriptive statistics involving these forecasts was not even possible in all but two cases. In terms of the operational definition of divergence (a sustained error of 10 cents per pound maintained after occurrance) even one of these two cases diverged shortly after the close of the sample period.

The conclusions regarding the comparison of the econometric models with the uncorrected trigonometric trend equations is that

the econometric models are not superior to this trend model. As shown in Table 54, the trigonometric equations produced better price forecasts than the econometric models in slightly more than half of the cases, but not enough to be significantly better than the models. Correcting the trigonometric trend model to reflect the forecasting error of the previous period resulted in improved forecasting performance in all cases but one (and this is the last comparison presented in the empirical chapter, Table 48).

The comparison of the trigonometric trend models (corrected and uncorrected) with the first difference model was operationalized by examining the U₂ inequality coefficient. Values of this statistic less than one indicate that the forecasting device being considered is better than the no-change extrapolation. For the uncorrected trend model, none of the U₂ statistics were less than one, while the corrected trigonometric trend model had 12 of the 22 U₂ statistics in that range. The insignificance of that difference left us with the conclusion that the corrected trend equation yielded forecasting performance approximately equal to the no-change or first difference model.

The performance of the difference models, other than the first difference model, was dominated by the performance of the

It might be instructive to examine at a later date the performance of these trend models vis a vis all variables of the econometric models. For example, in the Crom model, the forecasts of the quantity variables were much better than the price forecasts. Whether this was because of the model's superior performance, or due to better behaved data series, could be determined by such a study.

The verb "dominate" is used in this context to describe the situation in which all the measures of performance show the "dominating" procedure to be superior to the other procedure, for example, having

Table 54

Comparison of Econometric Model Forecasts with Trigonometric Model Forecasts

Model Number of Price Variables For Which the Econometric Model Uncorrected Trig Model Undecided Forecasts Better Forecasts Better According to According to According to Mean Square Correlation Mean Square Correlation Mean Square Correlation Error Error Error Hayenga 2 0 Hacklander 1 1 0 0 0 3 2 1* 3* Myers 1 Trierweiler 2 Hassler 3 0 0 4 Crom 4 3 2 3 0 0 0 2 2 0 0 Unger Total 8 12 11 1 3 9

^{*} The trig model was better than the structural model, but worse than the Stage I (reduced form) model.

first difference model on all the measures considered. The only exception to this is the performance of the hybrid difference model (first difference corrected by last year's forecast error) in forecasting the quarterly proce of utility cow beef at New York, from Crom's model. The explanation of this "deviance" suggested here, is the possibility that certain standard operating procedures on the part of meat processors may induce this "fluke" into the price series.

On the basis of the meager sample of three series of predictions, the conclusion regarding the futures market as a one month ahead forecaster of prices is that it is not significantly better than the current cash price in forecasting the nondeflated price of slaughter steers in the two terminals (Omaha and Chicago). The deflated futures market price; likewise, did not perform significantly better than the current deflated three market average cash price.

The relative performance of the low cost forecasting models did not change noticeably as the lead period between the forecast and realization increased. Specifically, the no-change model continued to dominate the other types of difference formulations. The futures price did not perform significantly different than the cash price (first difference formulation) over any of the lead periods, although at intervals of two and three months the futures market price had a slightly smaller mean square error than the current cash price as forecaster. The deflated futures price was negatively and

smaller values of the cost derived loss measures, smaller mean square error, smaller average relative error, larger correlation, etc.

significantly correlated with the three market deflated average price, but otherwise the pattern of performance for this variable paralleled that for the Omaha price. Of the two cash markets considered, the futures market price seemed to more closely forecast the price in the Omaha market.

Perhaps the most interesting of all the observations regarding the effect of length of lead period on the forecasts is that the futures market price in the early months of the contract, i.e. eight or more months prior to maturity, is virtually uncorrelated with the cash price in the month of maturity of the contract, and much less so than the prevailing cash price that same month. If this is more than just a sampling fluctuation, there is an opportunity for some sort of cash-futures arbitrage activity that in the short run might be personally quite profitable and in the long run, should possibly improve the ability of the futures market to predict prices near the maturity months.

Implications

The major finding in this research is that the value of the sophisticated econometric models studied in this analysis is less than that of the simpler models for generating price forecasts on a one-time-period-ahead basis, in spite of the reduced amount of information required for these simpler models. In particular, the econometric models performed less well than either the cash market price or the futures price in forecasting the cash price in the next time period (month, quarter, year), while the futures price and the current cash price each forecasted the cash price in the next

month about equally well. In light of this result, certain actions on the part of the producers, distributers, and consumers in the market for price information seem appropriate.

Price researchers should realize that, with their greater information content, econometric forecasts have the potential to provide much better information about future price levels than the current price levels, and certainly, than the econometric models studied in this thesis. To realize this potential, continued or increased efforts in the development of econometric models for the beef industry should be supported. While realizing that the current poor forecasting performance may have resulted from an orientation of the current models toward purposes other than forecasting, or simply reflected an underinvestment in beef price forecasting models, to improve the performance of future models an explicit attention to the forecasting performance of models developed should be a part of the evaluation of these developmental efforts.

Those charged with keeping the forecasts current and disseminating the price information (e.g. extension outlook specialists)
should maintain a record of the performance of the different methods
they used to derive their forecasts. In this way they would be able
to tell when a particular model, or the price and income elasticities
and other information derived from it, are out of date and need to
be revised or updated. Some of this same information can be used
to extend the life of the models by adjusting them to correct for
the serial correlation of disturbances which typically affects many

forecasting models. 1 (When the trend models in this study were corrected in this manner, the degree of improvement was substantial.)

The implications for farmers and other consumers of forecast information are threefold: First, they should maintain some degree of skepticism regarding the information they receive on prices from all sources (basically reflecting the fact that the corresponding forecasting errors have nonzero variances). Second, they should give explicit consideration to the cash and futures market prices for forecasting information in addition to other sources. Finally and most importantly, with the current state of the art as indicated by the models studied herein, they cannot afford to pay very much for private forecast information without substantially documented information regarding the past performance of the model and the service. (The successful commercial forecasting models are so as a result of the resources which are committed toward developing, revising, and updating the basic model and the expertise and judgment used in conjunction with the model's use.) Thus, the user is faced with the decision as to how to aggregate the individual forecasts to obtain one which would perform better than any single forecast. One relatively simple scheme would weight the individual forecasts inversely by the respective standard deviations of the forecasting errors (or root mean squared errors). A minimum variance unbiased aggregate would use weights based upon all the

Some of the forecasting devices currently being used consist of looking at the current price and then correcting that in accordance with the changes foreseen by some model, more or less reversing the process of correcting for serial correlation as indicated above.

elements of the covariance matrix of the forecasts, rather than just the diagonal elements of that matrix.

For those who service the users of this price forecast information (e.g. the managers of a "Telplan"-type operation or consulting group), an appropriate format for the information which they provide might include a statement of each of the individual price forecasts, including the current prices in both the cash and futures markets, together with one or more aggregates of the forecasts. It would also be instructive to include with the actual forecasts an indication of how the respective methods performed in the past.

Recommendations for Further Research

This set of recommendations will also be subdivided along the theoretical-empirical dichotomy which has been used in the organization of this thesis. There are a host of minor points and suggestions sprinkled throughout the body of the thesis, but the recommendations suggested in this section achieved this position because of the fairly direct relation that they have to the intellectual development outlined in this thesis.

Teigen, Lloyd D., "How should projections by various sources be consolidated into a single value for purposes of computerized consulting?" unpublished manuscript, July 24, 1970. The major drawback to an aggregation process of this form is that the elements of the covariance matrix are almost never known a priori. To empirically determine these elements, one would have to undertake an evaluative process similar to that pursued in this thesis to develop the data from which the variances and covariances are calculated.

In the theoretical vein, there are two main suggestions for research, namely to extend the concept of the cost derived loss function, and to establish the statistical properties of the Bayesian estimators which use the current and extended loss functions derived by representing the loss as the profit foregone from the inaccuracy of the forecasts.

assuming a one product firm whose output price is being forecast, and the aggregate interpretation of this function implicitly assumes an infinitely elastic demand function. The obvious extensions of this analysis include the evaluation of the loss resulting from the imperfect forecasting of input prices, the losses which accrue when both input and output prices are imperfectly forecast, and to the case of a multiproduct firm. In the aggregate analysis, there is the problem of representing the welfare loss, in a producer or consumer surplus sense, resulting from forecasting error when the demand elasticity is finite. Each variation of the basic assumptions would be expected to result in a different form of the loss function representing the costs of forecasting error.

For each of these loss functions there is a corresponding Bayesian estimator or forecasting rule. In the case of the current cost derived loss function it is the same as the estimator derived by the Bayesian analysis of the quadratic loss function, namely the posterior expectation of the dependent variable under study. The properties of the estimators depend in part upon the prior distribution of the dependent variable, as well as the loss functions assumed, so consequently there are many opportunities for econometric research involved in Bayesian estimation and analysis.

Virtually all the empirical results obtained in this thesis are contingent upon the assumption that the data used in this analysis are comparable with the data used in the original researchers' estimation process. To eliminate data problems as a factor contributing to the probability of (in this case, type I) error in the analysis, if this experiment were to be replicated, I would recommend the chosen models be re-estimated over their original sample period with the data defined in the same manner as that used in the test period. The re-estimated models would then be the subjects of evaluation, rather than the estimates as published in the source of the original models.

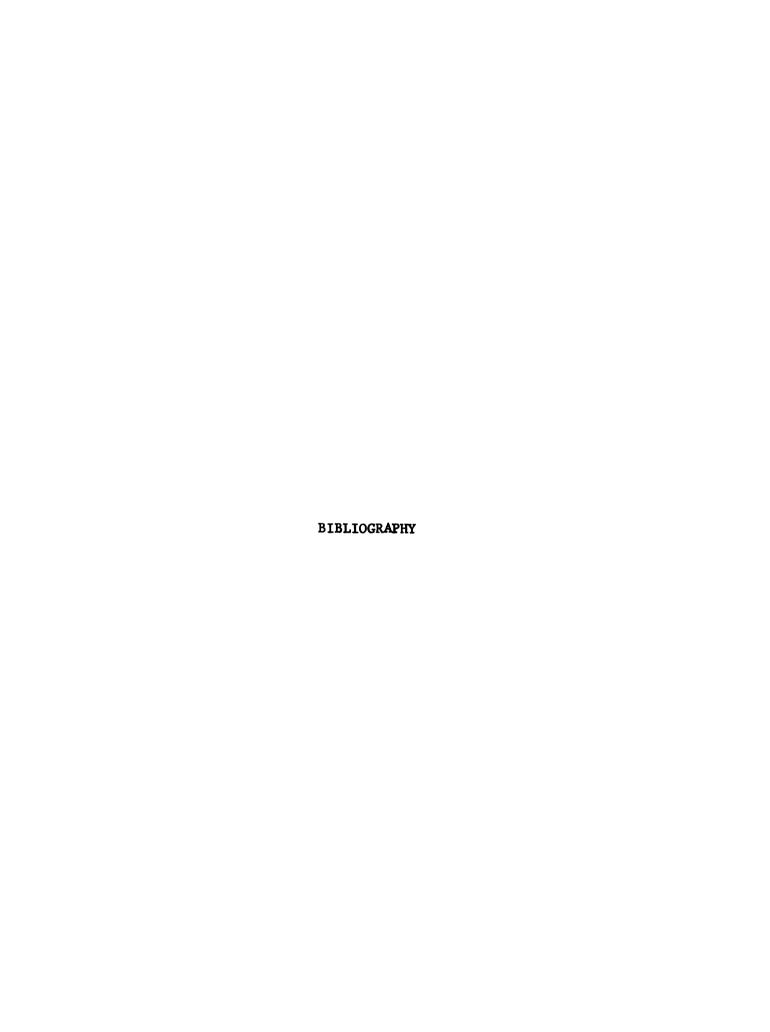
In the empirical analysis, the two surprising points arising in this research were the apparently poor performance of the econometric models and the unexpectedly good performance of the low cost models. These points form the basis for the recommended empirical research.

It appears that there is yet to be developed and published a stable dynamic model of the beef industry which can be used for short term forecasting of prices. The real challenge of this recommended direction of research is to obtain such a forecasting model which will consistently out perform the naive extrapolations of a no-change model, or better yet, from a financial standpoint, out perform the commodity futures market.

The unexpectedly good performance of the models which contained no more than present and previous cash prices and the corrected trend models as forecasting devices suggests that perhaps a better still forecast might be obtained by an "optimal" weighting of such

observations and past errors. The time series modelling techniques developed by Box and Jenkins consist of algorithms to efficiently estimate the parameters in such weighted average types of models, including provision for the incorporation of autoregressive disturbances of various forms. These estimates may result in an even better sort of "naive" standard against which the econometric models should be compared.

In view of the disappointing performance of the econometric models considered in this comparison, one must fervently hope that the future models of this and other industries, which involve reasonably large commitments of resources for their development and analysis, would perform more in accord with the costs-returns expectations which formed the basis for the expectations within this research.



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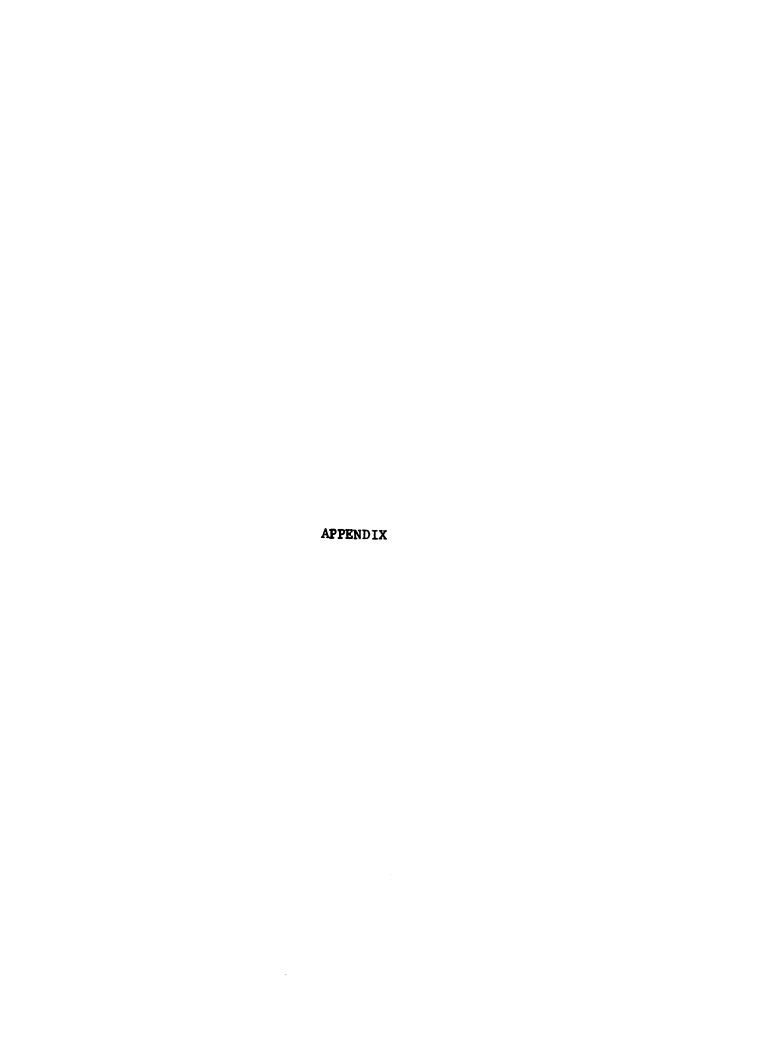
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APPENDIX

OBSERVATIONS REGARDING THE ANALYSIS OF AND THE DATA FOR THE ECONOMETRIC MODELS

This appendix to the thesis consists of two parts. First, the general procedure for analyzing the econometric models is described, and the departures from this procedure which were necessitated by the particular models are noted. Then, the data which were used in the analyses are described in terms of their characteristics and shortcomings: in a sense, how they were generated, manipulated and fabricated.

Analysis of the Econometric Models

In this section of the appendix, the general method of analysis of the econometric models is discussed, after which the three special cases in which this general method was altered are each described. The three cases which require some degree of explanation were the models of Myers, Trierweiler and Hassler, and Crom. The analysis of the models developed by Hayenga and Hacklander and by Unger followed strictly the general procedure.

An econometric model in the sense used in this thesis is construed to be a multi-equation system which represents the structure and behavior within a segment of the economy (in this case the beef cattle industry). In the compact form facilitated by matrix notation, such models may typically be represented as A Y(t) = BY(t-1) + C X(t) + U(t), where A and B are $n \times n$

matrices of (constant) coefficients, C is an n x m matrix of coefficients, X(t) is an m x 1 vector representing one observation of the set of exogenous variables, and Y(t) and U(t) are $n \times 1$ vectors, representing the observation of the set of endogenous variables (Y) or the realization of the multivariate unobservable disturbance process (U) which occurred at time t. Unless this system is recursive, the structural form of the system of equations cannot be used as it stands to generate forecasts (or evaluate policies, or do anything other than test structural hypotheses). In order to generate forecasts from the structure of the system, incorporating all the information embodied in that structure, one must invert the structure to obtain the reduced from for that system. In the sense that I am using the expression, the reduced form of the original structure is the vector equation: $Y(t) = A^{-1}B Y(t-1) + A^{-1}C X(t) +$ A-1U(t). For purposes of generating forecasts more than one time period into the future, the general solution of the difference equation should be derived.

Myers' model presented several difficulties in its analysis. The matrix of structural coefficients for the endogenous variables was not in fact constant, but a function of population, an exogenous variable. The procedure used to solve this problem was described in Chapter III, and involved inverting the matrix by partitions and representing the inverse matrix as a matrix polynomial in the population variable.

A system of equations is recursive if the rows and columns of the A matrix of the structural system can be permuted to form a matrix which is triangular. That is, it is recursive if all the elements above or below the diagonal of the A matrix are identically zero.

The stage one equations of the Myers model were at the same time the simplest and the most troublesome of the methods of forecast generation. They were simple from the standpoint that no matrix inversion was necessary to generate the forecasts. The troubles involved in these equations began when the particular exogenous variables used in these equations differed from one subset of equations to another, as well as from the form of the exogenous variables in the structural model. The structural model incorporated the income and broiler consumption as per capita variables and the pork storage holdsing variable as a total quantity variable. In the stage one equations explaining per capita pork consumption, per capita beef consumption and retail broiler price, the pork storage variable entered as a per capita variable, with the income and broiler consumption also as per capita variables. In all the other equations the income and the broiler consumption entered as total (as opposed to per capita) variables and the pork storage holdings were as a total variable. No discussion of the rationale for this deviation from the standard procedure of using the same exogenous variables in the "reduced form" model as in the structural model was given, by Myers, although it was apparently done in an attempt to offset the nonlinearity of the structural form equations. In fact, there was no discussion of the stage one equations in the bulletin or the thesis, except to say that "these forecasts were generated by them".

In addition to these problems of a substantive nature, several typographical errors were uncovered when the table of coefficients in the bulletin, was compared with the corresponding thesis table.

The coefficients of the dummy variables for June in the commercial hog slaughter equation and for August in the per capita pork consumption equation to be corrected: in the first case, the coefficient of -64.53 in the bulletin should have been -264.53; and in the second case, the published coefficient of -2.53 should have been -0.253. The coefficient of cattle on feed in the per capita beef consumption equation was reported to be 3.41 when it should have been 3.041.

The performance of the slaughter steer price equation indicates that this equation apparently has an error in it which was consistent between the Myers thesis and the bulletin. My suspicions concerning the error center on two coefficients, based upon a comparison of the coefficients from this equation with those of the retail beef price equation: The coefficient of the hog cycle variable in the retail price equation is positive and negative in the slaughter price equation leading me to suspect an incorrect sign; and the absolute magnitude of all coefficients in the slaughter price equation is smaller than the magnitude of the corresponding coefficient of the retail price equation, except in the case of a dummy variable and for the interest rate, whose coefficient is given to be -0.403. If the coefficient of the interest rate were -0.103, the amount of error observed between the forecasted and realized price would be significantly reduced (the possibility of mistaking a one for a four in a manuscript is not remote). It is this latter discrepancy that I have the higher degree of belief in, although I have not empirically verified the actual truth or falsity of the suspicion.

The Trierweiler-Hassler model varied from the standard model in that it contained both monthly and quarterly relationships. Although the monthly relationships contained only one exogenous variable which possessed monthly variation, one would be hard pressed to accept the joint determination of both monthly and quarterly variables at any point in time. Consequently, this model was analyzed by determining the quarterly variables separately from the monthly ones and evaluating those forecasts, and then analyzing the monthly relations with the realized values of the retail prices (the quarterly endogenous variables) read into the model as if they were predetermined in the analysis. There was one relationship which was specified in two alternative ways in the Trierweiler-Hassler bulletin. Both forms were included in this analysis by assuming that the calculated values from each of the forms were representing separate variables (although they had the same series of realized values). The recursive nature of the model facilitated the separate consideration of the quarterly from the monthly relations, but this property was not utilized further in the analysis.

The Crom simulation model was a dynamic recursive system of equations which included a number of nonlinear equations, as well as many (147) operating rules constraining system behavior in various circumstances. These nonlinearities and constraints precluded the matrix inversion method of generating the forecasts, although they were easily incorporated in the computer program which he used to simulate the beef and pork sector. While verifying the program that was included in the Crom publications, I noted that there were a number of places where there was a degree of

disagreement between the model as discussed in the bulletin's text and the model as operationalized in his computer program. Such things as extending the operation of binary variables beyond the period mentioned during the estimation, and thresholds for the operating rules not being the same in both the discussion and the program are typical of the discrepancies uncovered. In this analysis, whenever there was any amount of disagreement between the text and the program, the latter was given precedence in resolving the issue.

As regards the empirical results of the Crom model during his validation period (1955-1970), with the help of a duplicate deck of data cards provided by Mr. Crom, I was able to duplicate all but 28 of the more than 1600 computed values of the endogenous variables, and these 28 errors included those which were simply rounding errors. However, 13 of the 28 errors occurred in the second quarter of 1969, with virtual agreement on all the calculated values of the endogenous variables in subsequent quarters. This would lead one to suspect that the results for that quarter may have been incorrectly transcribed, or perhaps altered after computation - although only 7 of the 13 were closer to the realized values in the publication than in my results.

In my analysis of the Crom model all of the actual data in his bulletin were assumed to be correct. There was some attempt to verify the values of some of the series but not all were completely checked.

As was indicated earlier, both the Hayenga-Hacklander and the Unger models were analyzed according to the standard procedure indicated at the beginning of this section. Now I will describe

some of the difficulties encountered in the preparation of the data for use in the analysis of the models.

Data Generation, Manipulation, and Fabrication

The conclusions regarding the evaluation of the econometric models are conditional upon the data upon which the analyses are based. If the data used in the period of comparison are not defined the same as the data used in the estimation period, then a major portion of the error of forecast based on those models must be ascribed to the noncomparability of the data. With data revision, correction and occasionally elimination, there is a problem the ex post analyst must solve prior to his evaluative research, and that is the problem of data comparability. The publication by the original investigator of the data used in his estimation can be a very significant assist in the ex post evaluation of the model.

In all of the econometric models which were considered, there were some changes required in order to obtain comparability in the data series. In the Hayenga-Hacklander there were two variables for which some additional work had to be done to obtain comparability, the price of barrows and gilts at Chicago and the cattle on feed variables by weight groups. When the Chicago terminal ceased handling hogs in 1970, a substitute price variable had to be found. The price at Peoria, Ill., is the variable that replaced Chicago in the <u>Livestock and Meat Statistics</u> and was the primary choice to replace the Chicago price. However, for January through May of 1970, no price was reported for the Peoria market. For these months the adjusted price was taken to be the price reported at South Saint Paul plus a 30¢ per hundredweight adjustment.

The cattle on feed variables did have a degree of noncomparability during the sample period, as well as outside the sample. In the sample the variables were the 28 state totals for the period April 1, 1963 to April 1, 1964 and for April 1, 1964 through April 1, 1969 the 32 state total was used (the sample period was through June 1968). In July 1969, the U.S.D.A. began reporting cattle on feed numbers for 22 states on a continuous basis. These inventory numbers were adjusted to achieve comparability with the 32 state numbers as follows:

32 state 700-899# steers = 22 state 700-899# steers + 110 (1000 head)
32 state 900-1099# steers = 22 state 900-1099# steers + 69 (1000 head)
32 state 500-699# heifers = 22 state 500-699# heifers + 62 (1000 head)
32 state 700-899# heifers = 22 state 700-899# heifers + 39 (1000 head)

It it is true that the Myers econometric models gave me the greatest amount of trouble in the generation of the forecasts themselves, it is likewise true that the Myers data created the most problems in obtaining comparability. Most of the associated problems involved the exogenous variables, although there were two points of potential disagreement in the set of endogenous variables. In the set of endogenous variables, the least troublesome of the questions involves the choice of weights in forming the weighted average steer price from three markets. Myers indicates that the weights he used were the "relative value share based on total yearly sales for the three markets". The prices in my analysis were weighted by the yearly salable receipts of cattle for the respective markets in the previous year divided by the total receipts by those three markets that year. The effect of the different weighting schemes should be minimal, especially since the "value share" should be highly correlated with the salable receipts.

The other possible problem in the set of endogenous variables involves the retail price variables for both beef and pork. In 1969, the retail price series for beef and pork were revised by the U.S.D.A. to reflect coverage of more cities and giving different weightings to the individual cuts of meat, reflecting changes in consumer tastes, through a revised "market basket". Both series were revised back through January 1966, based on the newer definitions. Because the old series is the series used in the estimation, it was decided to retain the old series for as long a period as is possible to maintain comparability.

In the set of exogenous variables, there was no problem involved in duplicating the interest rate, price of corn, pork storage holdings and time variables. In the cases of the wage index, per capita disposable income and the cattle and hog cycle variables, I was satisfied that the variables I used were distributed randomly about the variables Myers used with a finite variance and no apparent biases. The per capita broiler consumption in month t was calculated based on the broiler chick placements two months earlier adjusted for mortality, average liveweight per bird, and dressing yield as well as exports and changes in storage stocks. The problem here was to aggregate thw weekly chick placements to monthly totals when some months have five weeks and some have four. The solution arrived at was to adjust all months to a

An adjustment of \$2.00 was subtracted from the income variable to obtain agreement of this data with Myers data in the sample period.

four and one-third week basis, based upon the average weekly placements within the month in question. The resulting per capita broiler consumption was distributed with mean equal approximately to Myers series for that month and some variance greater than zero. The exogenous variable representing the number of hogs six months old and older was one series in which there was a noncomparability of this post-sample observations with his sample observations, apparently because the sample series was not calculated according to the same method as outlined in the appendix to the bulletin (his post-sample values agreed with this method). The problem then became one of how to commit the same error as was committed in the process of obtaining the estimates. For months other than December, the procedure was to take the beginning hog inventory, add the pigs born seven months earlier adjusted to reflect survival rates, subtract off the month's portion of the breeding herd adjustment and farm slaughter, and also subtract off the number of hogs slaughtered in the previous month. For each December the inventory of all hogs on farms weighing 180 lbs. or more plus 25 percent of the number of hogs weighing between 120 and 180 lbs., plus the number of pigs born seven months earlier expected to survive to marketing (sows farrowing times average litter size times one minus the death loss as a percentage of the pig crop), were added to form the value of this variable (i.e. it is reinitialized each December). (In the bulletin, Myers suggests using the unadjusted December inventory.) The resulting variable appeared to have Myers variable as its mean during his sample period, but did show variability about this mean. The twenty-six state cattle on feed series had to be interpolated

in the latter months of the test period, as a result of the U.S.D.A. decision to report cattle on feed in twenty-two states after 1969, except for the January inventory.

The Trierweiler-Hassler bulletin was perhaps one of the less specific papers in terms of the descriptions of the data and the sources. In addition to this, no tabulation of the sample data was published. Notwithstanding this drawback, there were only two variables about which there was any question, the slaughter hog price and the beef carcass price. The problem associated with the hog price was that I was unable to locate an Omaha price of hogs for observations early in the sample period (for use in obtaining the trend approximations). As the way around the difficulty, I substituted the corresponding National Stockyards price minus 15¢ per hundredweight to fill the gaps in the data series. The problem with the carcass price was that the bulletin referred to it only as the price of "Choice 600-700 lb. Beef Caracsses at Chicago", without specifying whether it referred to steer carcasses, heifer carcasses, or an average of the prices of both types of beef. For my analysis, I assumed that it referred to the price of steer carcasses.

The Crom model also was rather non-specific as to the origin of its data, although it did include a listing of the data used in the sample period, as well as in the validation period. I did have some difficulty in locating some of the data series used in his model, as well as determining the content of several variables which he created specifically for the model. In the former category were such variables as the byproduct credits allowed for both beef and pork, and the marketings of nonfed beef, the two variables in

the latter category are the commercial beef cow slaughter and the inventory of heifers one to two years old, not on feed. Because the bulletin contained data through the second quarter of 1970, it was decided that the marginal gain of another couple quarters' data, would be less than the marginal cost of obtaining the data. Consequently, the test of the Crom model covered the time period from the third quarter of 1964 to the second quarter of 1970, rather than the period from the first of 1965 to the last of 1970, as in the case of the other models.

The Unger thesis was the most specific as regards the data sources and content. Not only did he include the sources of the data and a listing of the data, he also included the table number of the most recent year's observation of the data together with the source. Even with this there were some problems that needed to be solved. One of the data series which he used in the estimation process was discontinued from publication in the Agricultural Statistics handbook, and there was some discrepancy involving the construction of one of the data series. The publication of the "cost of marketing meat" variable was discontinued in the 1965 issue of Agricultural Statistics which presented for data for 1964. However it did retain the "meat products marketing spread" which represented the marketing costs included in the typical "market basket" of meats for a family. To obtain a variable comparable in content to Unger's original variable, I divided this "meat products marketing spread" by the per capita consumption of all metas multiplied by the average family size. To adjust this series to the value of Unger's original variable in his last observation, 1.10 cents per

pound was added to this ratio. His price of protein feed variables was the other problem. In his discussion of the data, he implied that the price of Copra meal was included in his index, while Hildreth and Jarrett (36), his model in the construction of this series, did not include the price of Copra meal in their index. Since he stated that Hildreth and Jarrett's method is the way that he obtained the variable, that was the method I chose to resolve this problem. Also, there was the necessity of converting the feed prices from dollars per ton to dollars per hundredweight of total digestible nutrietns. Whether or not that particular price variable was included in this index should probably not substantially affect the values of this variable since there were eleven other price variables entering this index.

The final set of data which was used in this thesis involved the prices of the live cattle futures contracts on the Chicago Mercantile Exchange. As has been mentioned in the main part of the thesis (Chapter III) these data were assembled into weekly average prices by Keith Holaday Lacy in his Master's thesis. I further combined these weekly averages into monthly averages. In determining to which month a particular week belongs, the following rule applied: A week is classified into the same month as the Wednesday of the week. This means that a week which ends on Saturday the third, would be classified with the preceding month's observations. When the futures market price was deflated to make it comparable with the deflated slaughter steer price, the deflating price index for the month in which the futures price was observed was used rather than try to account for any potential changes in the price index between the month of forecast and the month of the realization.

I am including listings of the exogenous and realized endogenous variables for each of the models, as well as the forecasted endogenous variables correponding to each form of the models as an assit to the reader, or subsequent user of this thesis. Also included is a copy of the performance statistics on all endogenous variables corresponding to each run of the models. Finally the reduced form equations which correspond to Myers' Structural Model are presented.

Table Al

EXOGENOUS VARIABLES USED IN THE MAYENGA AND MACKLANDER MODEL

YEAR	HONTH	WKDAYS	PCOW	1	\$ 7	5)	H 5	H 7	P 48	P 120	P 168
1965 1965	1	22.2 21.3	23.1 21.6	2.666 2.663	1799. 2097.	1853. 1767.	610. 872.	82 0. 832.	10312. 10312.	8246. 8246.	5239. 5239.
1965 1965	3	24.3 23.3	20.4	2.675	2097.	1767.	872.	832.	10312.	8246.	5239.
1965	•	23.3	20.0 21.5	2.684 2.719	2097. 1976.	1757. 162.	672. 1337.	832. 714.	6805. 6805.	7752. 7752.	4556. 4556.
1965 1965	6	23.3 23.2	24.1 25.9	2.738 2.752	1978. 1978.	162%.	1337.	714.	6805.	7752.	4556.
1965	•	23.3	26.1	2.761	2459.	162. 1653.	605.	714. 1192.	8033. 8033.	5173. 5173.	2750. 2750.
1965 1965	10	22.0 22.7	27.1 26.7	2.633 2.603	2459. 2459.	1655. 1655.	805. 805.	1172. 1192.	8033. 10038.	5173. 6729.	2750. 4788.
1965 1965	11	22.8	30.8	2.430	1918.	2095.	750.	1024.	10038.	8729.	4758.
1707	12	24.0	24.3	2.853	1918.	2005.	750.	1024.	10036.	8729.	4788.
1966	1	22.3	24.0	2.861	1916.	200	750.	1024.	8860.	6834.	4263.
1966 1966	2	21.3 24.3	24.6	2.841	2339.	179	1091.	975.	8850.	5834.	4263.
1966	•	22.7	22.0	2.906	2339.	179	1091.	975. 975.	8860. 6167.	6834. 7173.	4263. 3918.
1966 1966	5	22.6 23.3	20.5 20.6	2.916 2.935	2312. 2312.	1965.	1434.	983. 943.	6167. 6167.	7173. 7173.	3988. 3988.
1966 1966	7	22.2	21.1	2.970	2312.	195	1434.	953.	8352.	5125.	2649.
1966	•	24.3 22.8	21.2 21.5	2.99 0 3.012	2590. 2590.	190). 190).	965. 965.	1319. 1319.	8352. 8352.	5125. 5125.	2649. 2649.
1966 1966	10	22.7 22.8	27.4 24.1	3.026 3.047	2590. 2070.	1961. 2175.	965. 755.	1319.	10903. 10903.	9452. 9452.	4955. 4955.
1966	15	23.2	22.4	3.050	2070.	217	755.	1000.	10903.	9452.	4955.
1967 1967	1	22.8 21.3	21.9 20.0	3.063 3.092	2070. 2633.	217 i. 200 i.	755. 1031.	1000.	9938. 9938.	7858. 7858.	5022.
1967	3	24.3	19.0	3.105	2633.	200	1031.	1047.	9938.	7858.	5022. 5022.
1967 1967	•	21.7 23.8	17.0 17.8	3.106 3.122	2633. 2346.	200 207 I.	1031. 1400.	1047. 895.	6754. 6754.	7728. 7728.	4470. 4470.
1967 1967	6	23.3	18.3	3.146	2346.	2071.	1400.	895.	6754.	7728.	4470.
1967		22.2 24.3	28.8	3.163 3.182	2346. 2442.	2071. 2050.	1400. 871.	895. 1251.	8978. 8978.	5512. 5512.	292 9. 2929.
1967 1967	1	22.2 23.3	20.3 21.3	3.193 3.194	2442. 2442.	2054. 2054.	871. 871.	1251. 1251.	8979. 10332.	5512. 9562.	2929.
1967	11	22.4	22.9	3.226	2029.	221 1.	.858	1038.	10332.	9562.	5130. 5130.
1967	12	22.2	21.6	3.262	2029.	221 J.	626.	1038.	10332.	9562.	5130.
1968	1	23.6	20.5	3.271	2029.	221 1.	.050	1030.	10080.	7566.	4977.
1958 1968	3	22.3 22.7	18.9 18.2	3.309 3.362	2494. 2494.	2011. 2011.	1108. 1108.	1102. 1102.	10088. 10080.	7566. 7566.	4977. 4977.
1968 1968	5	23.3 23.8	17.5 17.4	3, 352 3, 377	2494. 2396.	2011. 2043.	1106.	1102.	6950. 6960.	7972. 7972.	4505.
1968	6	21.7	14.2	3.402	2396.	204 5.	1620.	961.	6960.	7972.	4505. 4505.
1968 1968	7	23.8 23.7	19.5 19.9	3.426 3.447	2396. 2655.	2043. 2044.	1620. 929.	961. 1437.	8695. 8695.	5646. 5646.	3090. 3090.
1968 1968	10	21.8	20.1 21.6	3.472 3.486	2655. 2655.	204%. 204%.	923.	1437.	8695.	5646.	3090.
1968	11	22.2	22.2	3.506	2350.	225?.	929. 1025.	1437. 1146.	10750. 10730.	9736. 9736.	527 0. 527 0.
1968	12	22.0	24.0	3.530	2356.	2252.	1026.	1146.	10730.	9736.	5270.
1969	1	23.6	19.9	3.554	2150.	2252.	1025.	1146.	10855.	8294.	5101.
1969	2	21.3	19.2	3.577	2742.	2261.	1236.	1177.	10655.	8294.	5101.
1969 1969	3	22.7 23.3	16.9 18.5	3.608 3.627	2782. 2782.	2261. 2261.	1236. 1236.	1177. 1177.	10865. 7169.	8294. 8138.	5101. 4652.
1969 1969	5	23.2	14.3	3.647	2532.	2241.	16/3.	915.	7169.	8138.	4652.
1969	7	23.4	20.2	3.674 3.697	2532. 2532.	2241. 2241.	1673. 1673.	985. 935.	7169. 8970.	8136. 5760.	4652. 3334.
1969 1969	•	22.7 22.8	19.9 19.7	3.724 3.736	3221. 3221.	2252. 2252.	1209. 1209.	1524. 1524.	8976. 8970.	5760. 5760.	3334. 3334.
1969	10	24.3	20.4	3.748	3221.	2257.	1207.	1524.	9600.	A569.	4980.
1969 1969	11	21.2 23.6	20.8 19.6	3.763 3.774	2708. 2708.	255 to	1064.	1319. 1319.	9600. 9600 .	8569. 85 69.	4980. 49 88.
					,						
1776	1	23.2	10.9	3.406	2708.	251.1.	1064.	1319.	9492.	7362.	4575.
1970 1976	3	21.3 23.3	17.3 16.8	3.621 3.646	2853. 2853.	23-1. 23-1.	1303.	1204. 1204.	9872. 9472.	7362. 7362.	4575. 4 575.
1970		23.3 23.3	16.9	3.935	2453. 2493.	2311.	1385.	1204.	7100.	7682.	4421.
1976	•	23.3	16.5	J. 690	2493.	23910	1710.	1076.	7100. 7130.	7482. 7682.	4421. 4421.
1978	′	26.0 22.7	17.6 17.1	3.911 3.922	2493. 3073.	234	1710.	1076.	9653. 9653.	6061. 6061.	3371. 3371.
1978	•	27.8	16.9	3.945	3073.	23170	1174.	1598.	9651.	6061.	3371.
1970	11	23.7 21.6	14.1	3.911 3.940	3073. 2786.	21/1. 2631.	967.	1574. 12 65.	11224.	9494. 9494.	5188. 5188.
1970	15	23.6	14.0	3.760	2706.	2611.	967.	1265.	11224.	9494.	5144.

Table A2

MAYENGA AND MACKLANDER MODEL ACTUAL AND ESTIMATED ENDOCENOUS VARIABLES

YEAR	HONTH	PC	EST PC	qc	EST QC	PH	EST PH	Фн	EST QH	STOR	EST STOR
1965	1	23.93	23.43	69.324	59.523	17.36	23.15	45.676	34.189	309.	248.
1965	ž	23.66	22.14	64.005	60.572	17.93	25.35	40.939	28.841	313.	262.
1965 1965	3	24.30 25.20	23.57 22.03	64.527 61.073	64.993 61.291	17.98 18.76	37.40 23.79	44.239	11.538 32.570	335. 335.	178. 319.
1965	š	26.56	21.58	64.459	60.449	21.59	19.29	36.171	40.754	292.	333.
1965	6	26.97	25.42	65.665	63.452	24.55	39.15	34.506	8.452	226.	111.
1965 1965	7	26.18 26.68	22.33 23.08	65.517 67.253	58.716 62.443	25.14 75.40	24.23 29.36	32.543 34.592	33.235 25.604	176. 135.	178. 83.
1965		26.40	22.74	71.220	62.402	23.63	20.24	40.219	43.806	126.	142.
1965	10	26.30	24.80	70.617	63.808	:4.48	33.49	40.529	22.915	128.	47.
1965 1965		26.21 25.18	24.29	68.860 66.942	60.132 61.660	75.64	32.41	41.889 35.958	26.920 21.785	142.	77. 60.
1707	12	274.14	23.87	00.442	02.000	!9. 22	36.42	37. 176	611,07	152.	•••
1966	1	26.74	27.12	74.215	64.649	29.58	41.58	37.130	12.471	155.	33.
1966	2	27.63	24.00	68.779	66.914	?9.14	42.08	37.934	11.760	183.	52.
1966 1966	3	28.99 27.98	26.56 25.28	66.008 66.344	68.618 62.393	25.71 ?4.18	49.38 32.73	41.399 40.617	.200 25.386	217. 272.	12. 189.
1966	•	26.72	22.68	69.254	64.385	25.36	24.25	38.377	38.142	265.	268.
1966	6	25. 19	24.17	72.918	66.837	:5.36	37.29	36.094	15.925	214.	126.
1966		25.28 25.61	20.78	70.090 71.317	65.766 68.005	26.01 26.37	22.48 27.42	33.649 36.173	39.714 32.019	179. 140.	198. 113.
1966 1966		25.70	22.25 21.61	75.132	67.374	. 4.06	18.10	43.421	49.939	151.	173.
1966	10	25.20	24.46	73.304	69.816	22.71	33.63	45.330	24.664	171.	71.
1966		24.75	23.59	72.237	64.411	71.03	28.19	48.377	34.638	506.	145.
1966	12	24.54	21.85	70.603	64.137	!2.13	24.28	47.716	41.378	234.	284.
1967	1	25.34	24.94	75.789	67.231	21.22	27.51	48.509	34.555	256.	283.
1967	ž	24.90	22.14	72.254	68.440	20.02	. 24.27	45.775	39.849	293.	263.
1967	3	24.53	23.22	69.712	73.159	.9.58	34.21	46.708	23.139	331.	208.
1967 1967	5	24.29 25.05	21.40 20.66	73.548 73.992	69.428 69.315	:4.60 :3.33	19.88 14.41	47.851 39.834	44.993 51.817	386. 336.	371. 420.
1967	í	25.45	24.39	75.064	74.637	13.72	37.91	39.485	14.365	293.	167.
1967	7	25.99	20.96	72.207	68.969	:3.65	19.43	37.748	43.676	237.	276.
1967	•	26.66	24.87	71.564	68.267	21.60	25.63	41.646	33.237	199.	164.
1967 1967	10	26.94 26.82	22.46 25.13	74.234 74.163	65.129 67.998	.:0.29 19.34	9.20 25.50	47.117 49.614	62.604 36.429	203. 250.	281. 169.
1967	11	26.31	24.57	70.877	63.450	19.07	21.25	50.038	63.238	279.	248.
1967	. 12	26.08	23.49	71.757	64.378	19.11	20.92	49.324	44.678	286.	276.
1968	. 1	26.96	25.43	75.462	65.814	19.53	18.62	48.319	47.889	289.	309.
1968		27.81	23.69	73.229	67.168	20.36	18.69	44.215	47.414	291.	329.
1966 1968		26.05	25.84	71.454	70.832	19.90	31.34	46.748	29.692	306.	234.
1968		27.79 27.37	24.56 22.86	70.300 75.504	66.396 69.460	20.05 20.49	17.97 14.22	47.811 46.723	50.227	355.	376.
1968	6	26.68	25.48	75.453	73.536	21.92	29.03	41.290	55.593 28.245	385. 326.	412. 274.
1964		27.61	22.10	75.210	69.923	22.59	14.36	39.622	52.681	245.	343.
196 R		27.78 27.90	24.54 22.81	75.907 7 9.266	69.160	20.67	18.85	41.963	46.662	197.	232.
1968		28.14	26.50	79.095	67.070 70.323	20.67 19.14	3.44 23.70	48.624 51.440	75.121 42.532	197. 222.	338. 191.
1966		28.48	24.10	74.955	66.568	18.90	15.29	51.532	57.553	237.	295.
1968	12	20.06	23.54	72.325	65.848	19.74	15.11	51.140	59.202	256.	312.
1969		29.12	26.43	78.025	67.546	20.44	15.66	49.160	57.045	249.	328.
1969		29.26 38.38	24.10 25.48	76.573 73.124	70.264 73.765	, 20.88	16.30	49.296	55.934	264.	337.
1969		31.11	25.12	73.12h 71.545	70.116	?1.26 ?1.11	25.80 16.94	49.824 49.142	42.769 56.352	270. 324.	277. 377.
1969	5	33.68	24.90	72.629	70.200	24.13	13.76	44.310	60.107	299.	408.
1969 1969		34.07	29.69	74.709	72.399	?5.92	34.93	43.229	24.408	246.	184.
1969		31.54 30.40	26.96 25.73	74.160 76.38A	69.075 75.730	?o. 41 ?7. 02	22.98 25.22	48.756	43.748	195.	235.
1969	9	29. 13	25.13	41.360	78.209	?6.01	21.17	41.542 47.861	42.212 51.343	168. 174.	167. 191.
1969		29.79	26.51	62.099	80.171	25.97	30.98	48.889	36.017	202.	134.
1959	11 12	28.47 20.66	25.5A 25.19	77.406 75 .7 4 0	76.107	26.51	27.53	47.311	62.505	221.	147.
• , , , ,	••		67017	726744	78.361	27.61	33.45	46.597	34.651	211.	171.
1970		29.60 38.61	27.49 26.31	00.690 77.143	77.673 76. 057	!8.11	28.18	45.302	42.712	210.	215.
1970		31.46	24.54	75.536	81.015	!4.97 !6.66	29.71 41.23	43.615 46.140	39.696 21.516	237.	219. 156.
1970	4	31.48	24.00	16.524	77.052	24.79	27.54	48.738	42.142	269. 327.	146. 302.
1978		31.52	27.09	77.844	75.360	?4.76	20.92	45.516	50.376	351.	365.
1970		10.77 11.17	20.44 26.16	77.554 75.313	79.050	?5.46	33.57	42.103	27.423	304.	234.
1976		30.50	27.30	75.313 75.346	75.425 78.243	!5.79 !2.40	21.07 26.13	41.250 44.405	67.286 70.567	255.	243.
1970	•	30.71	24.60	01.910	75.741	?0.61	6.19	50.702	39.563 74.760	218. 213.	197. 345.
1978		27.40	26. 19	40.717	75.764	14.35	15.77	53.924	60.164	246.	242.
1978		79.18 21.19.	24.70 22.53	77.798 77.773	70.705	16.66		57.569	71.594	384.	346.
• • •	••	*****		******	72.234	16.36	4.17	57.647	79.261	336.	457.

HAYENGA AND HACKLANDER MODEL: Forecasting Performance

IND HA ON DA					1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	.86 30.25 65.47 203.43 53		.0271 .6632 .8492 .011; .6523	4.6187 1.8834 5.5396 4.6611 2.8731	32. 33. 45. 29.	3.22 4.68 6.48 11.53 59.01	11.45 6.38 29.11 26.5% 25.65	59.42 228.68 859.18 4601.8/ 602425.02	308.47 1907.25 13348.68 122544.67*296298.69	.7329 .7538 .5586 .6045 .7183	.8568 .6183 .2011 .2036 .4564	3.2080 4.1125 -1.8292 4.4670 14.7212
	COST DERIVED LOSS	M	N = 0.12	11		#	INEQUALITY HEASURES	U 13.	5 n	TURNING POINT ERRORS 27.	AVERAGE ABSOLUTE ERROR	AVERAGE RELATIVE ERROR	THIRD ARSOLUTE MOMENT	FOURTH MOMENT	COQRELATION .7	SLOPE	BIAS (AVERAGE ERROR) 3.2

NO OF OBSERVATIONS IN THE CALCULATION OF SAR SUBROUTINE = 72

191
Table A4

PROPENOUS ANIMATES ESED IN MACHE MODERS

							4						
YEAR HON!	н дър	ин	Ħ	PHCRII	Сн	46	CC	a	1	ОСН	POPM	CPI	WPI
1965 1965 1965 1965 1965 1965 1965 1965	319, 315, 335, 342, 274, 176, 175,	16245, 15.37, 1651, 18-27, 17.69, 14-97, 13.51, 12-13, 171.53, 2056, 15117,	4,00 4,10 4,19 4,29 4,29 4,24 4,26 4,27 4,25 4,25	1.2.8 1.275 1.293 1.3n8 1.332 1.3n4 1.23 1.244 1.243 1.154 1.101	1.009 .968 .976 .976 .964 .959 .939 .939 .939	952035 952035 952035 87272 87272 87272 76235 8426 92012	1:127 1:119 1:117 1:117 1:179 1:570 1:570 1:553 1:144 1:741	124:52 122:01 127:42 122:42 122:30 121:52 121:41 124:10 124:70 122:64	1/7 70 1/7 70 1/6 70 1/6 70 1/0 70 1/	2.113 2.177 2.217 2.513 2.517 2.577 2.676 2.555 2.364 2.219 2.172	193.48 193.81 193.81 194.17 194.37 194.37 194.39 195.30 195.30	108.9 10d.9 109;0 109;0 109;5 110.1 110.2 110.0 110.4 110.6	101:0 101:3 101:3 102:1 102:0 102:0 102:0 103:0 103:0 103:0 103:0 103:0 103:0
1966 1 1966 3 1966 3 1966 3 1966 3 1966 3 1966 1 1966 1 1966 1 1966 1	1"3, 217, 2'2, 208, 214, 179, 140, 171,	19.29, 14.36, 196.3, 27316, 16.64, 34.2c, 127-7, 17.15, 127-9, 15.140, 18.37, 17.424,	4,/5 4,96 4,96 5,18 5,37 5,56 5,75 5,75 5,75 5,60	1.23 1.22 1.146 1.213 1.412 1.49 1.36 1.36 1.36 1.348	6744 6869 68699 6999 997463	101712 102712 103272 103272 95272 65270 8370 82164 9712 87164 9712	1:033 1:034 1:034 1:035 1:035 1:035 1:035 1:036 1:056 1:056	122.66 121.33 121.33 121.21 121.17 121.17 122.17 121.17 12	147,94 110,01 114,14 110,10 110,42 114,43 114,43 119,24 119,24 119,24 119,24 119,24	2,431 2,431 2,533 2,652 2,834 2,837 2,837 2,437 2,437	195.86 196.01 196.16 196.32 196.71 197.11 197.11 197.14 197.77 197.77	111.0 111.0 112.0 112.0 112.9 113.3 113.3 114.1 114.5 114.5	104.0 105.4 105.7 105.7 105.7 106.8 106.8 106.8
1907 1 1967 2 1967 2 1967 4 1907 5 1967 7 1967 7 1967 10 1967 12	274, 271, 371, 377, 310, 273, 239, 179, 213, 270,	16855. 16244. 16774. 16774. 1927. 1923. 13324. 13413. 13677. 17037. 19499. 16055.	5, 23 4, 08 4, 68 4, 29 4, 27 4, 40 4, 77 4, 76 4, 40 4, 43 5, 43	1.316 1.302 1.302 1.302 1.292 1.295 1.295 1.273 1.150 1.150 1.073 1.073	1.014 1.064 1.125 1.125 1.124 1.129 1.139 1.142 1.149	10 9 3 1 1 1 1 0 4 6 1 1 1 0 4 6 1 1 1 0 2 7 5 4 9 7 1 2 2 9 1 4 0 1 8 5 3 3 2 8 4 7 4 2 8 4 1 8 2 9 2 / 1 2 1 8 1 2 5 8	1:059 1:049 1:046 1:046 1:034 1:034 1:034 1:034 1:034 1:034	126.90 126.90 127.90 127.90 127.45 127.45 127.44 130.75 127.50 127.14 131.47	172. v8 173. 13 173. 92 174. 92 174. 93 174. 93 175. 41 175. 41 176. 83 176. 83	2.467 2.454 2.541 2.541 2.671 2.671 2.671 2.771 2.771 2.771 2.771 2.771	178.11 198.27 198.42 198.90 198.96 198.94 199.31 199.32 199.72 199.72	114./ 114.6 115.0 115.3 115.6 116.9 116.9 117.1 117.3	100:2 100:0 100:1 100:1 100:1 100:1 100:1 100:2 100:2 100:2
1968 1968	245 176 177 272	17565. 16947. 17924. 18784. 15135. 12725. 14135. 17724.	5.43 5.43 5.79 6.84 5.64 5.64 5.64 7.77 6.28	1.026 1.037 1.054 1.078 1.040 1.000 1.000 . V72 1.031 1.035	1.105 1.051 1.064 1.044 1.045 1.047 1.035 1.035 1.024	109788 198024 198278 109418 109184 9364 91718 92701 10274 112408	1:1017 1:1017 1:101008 1:100995 1:10995 1:10995 1:10995 1:10995	138 46 131 30 131 28 131 28 132 79 132 37 132 37 136 56 136 73 136 73	197(3) 218(3) 218(4) 213(4) 213(4) 213(4) 213(4) 213(2) 213(2) 213(2) 213(2)	4429140747414444444444444444444444444444444	200.24 200.39 200.39 200.41 230.98 201.15 201.15 201.74 201.74 201.74 202.10	119:59 119:59 128:9 128:9 121:9 121:9 122:4 123:4 123:4	29 43-7/1/116 5 78 12 2 3-7/1/116 5 18 5 5 5 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1969	299, 7 246, 1 176, 1 106, 1 174, 2 . 2,	26717.	6.46 6.06 6.06 7.38 7.49 6.41 8.14 6.17 8.18	1.044 1.072 1.072 1.154 1.124 1.124 1.018	1.830 1.033 1.044 1.037 1.012 1.015 1.015 1.015 1.013	12146 11525 11525 11714 10703 10701 10520	11110 229 11110 229 11111 200 11111 200 11111 200 11111 200 11111 200 11111 200 11111 200 11111 200 11111 200 11111 200	136.87 134.89 135.78 135.78 135.59 137.08 136.59 136.59 137.46 140.56	1/9.91 2.0.43 2.0.19 2.0.70 2.0.67 2.	2.574 2.574 2.676 3.622 3.123 3.123 3.123 3.123 3.423 3.423 2.493 2.679	292.25 292.40 202.35 202.71 202.48 203.42 203.40 203.42 204.81 284.88	124.0 124.0 125.0 126.4 126.4 126.2 128.7 128.7 129.8 138.7 138.7 138.7	1111190 1111190 1111190 1111191 1111191 1111191 1111191 1111191 1111191 1111191
1778 1770 1770 1778 1978 1978 1970 1970 1970 1970 1970 1970 1970 1970	237, 269, 329, 371, 304, 275, 217, 210, 444,	15122. 14/90. 10165. 19162. 17/82. 14/55. 12174. 11/93. 14/44. 16/48. 21/22.	8.64 8.38 7.54 8.02 7.46 7.46 7.40 7.40 7.40 7.40 7.40 7.40	1.052 1.057 1.046 1.051 1.115 1.172 1.273 1.274 1.270 1.198	. 787 . 971 . 959 . 950 . 944 . 952 . 951 . 944 . 976	127/91 124/491 12:/91 11:/91 11:/91 11:/91 10:/191 10:/91 10:/91 10:/91 11:/91 11:/91	1:006 1:006 1:006 1:006 1:006 1:002	141.17 137.78 139.27 139.72 142.37 142.19 144.19 144.19 146.18 147.87	214,49 203,10 203,41 207;27 204,50 204,50 205,20 205,20 205,72 408,44 208,52	23.070 Y 49.070 Y 49.	204.J5 204.04 204.06 204.04 205.40 205.40 205.40 205.00 206.03 206.43	131.8 132.5 134.0 134.0 134.0 135.2 135.7 136.0 137.4 137.6	11000000000000000000000000000000000000

Table A5

HYERS STRUCTURAL HODEL
ACTUAL AND ESTIMATED ENDOGENOUS VARIABLES

(1)

					(1)					
YEAR MONTH	4 QH	EST QH	РН	EST PH	PP	EST PP	9 20	EST @0	PCH	EST PCH
1965 1	1675.	1420.	15.90	32.62	51.70	83.66	5.132	4.613	34.44	43.02
1965 2 1965 3	1439. 1756.	1427. 1150.	16.81 16.76	21.37 36.08	52.16 52.39	62.73 88.69	4.544 5.552	4.454	35.63 35.32	36.00 46.34
1965 4	1599.	1325.	17.34	28.05	52.42	74.41	5.135	4.346	35.32	41.07
1965 5	1327.	1170.	19.67	\$3.56	52.83	83.76	4.424	4.175	34.40	42.21
1965 6 1965 7	1340. 1231.	1217. 949.	22.74 23.59	32.27 38.90	57.86 61.98	81.J3 92.49	4.579 4.219	4.199 3.074	37.05 30.75	39.75 41.69
1965	1302.	683.	23.97	48.63	63.82	109.13	4.435	3.357	36.35	45.69
1965 9	1485.	360.	22.25	59.36	63.88	120.19	4.850	2.834	30.30	49.47
1965 10 1965 11	1494. 1535.	815. 791.	22.06 23.51	48.02 53.54	63.04 62.57	108.76 119.06	4.793 4.767	3.768 3.423	34.87 34.90	43.95 47.92
1965 12	1411.	605.	26.96	61.36	65.50	132.15	4.487	3.044	34.68	51.50
1966 1 1966 2	1338. 1245.	680. 706.	26.70 26.38	60.49 48.50	69.82 70.43	130.65	4.340 4.107	3.114 2.985	35.05 38.35	50.16 42.48
1956 3	1573.	526.	23.16	59.16	69.46	127.20	5.106	2.370	37.02	49.44
1966 4	1473.	795.	21.10	47.25	64.98	106.26	4.559	3.269	39.75	44.19
1965 5 1966 6	1418. 1359.	757. 999.	21.93 21.19	49.21 40.01	63.41 53.95	109.56 93.72	4.559 4.657	3.325 3.776	37.12 37.11	45.28 38.24
1966 7	1204.	1003.	23.50	37.05	64.34	88.34	4.068	3.79#	37.51	38.50
1965 8	1415.	1123.	24.11	33.74	64.41	82.51	4.713	4.167	35.99	36.65
1966 9 1966 10	1592. 1654.	1041. 1270.	21.69 20.31	34.68 31.96	64.68 63.23	84.66	5.052 5.138	4.103 4.532	30.63 34.76	35.87 34.93
1955 11	1755.	1300.	16.76	32.18	60.65	81.58	5.441	4.555	33.33	35.14
1966 12	1772.	1519.	18.57	31.25	\$3.0Z	80.37	5.532	4.833	35.04	35.43
1967 1 1967 2	1774. 1561.	1246. 1102.	14.32 18.28	41.96 35.91	58.85 38.10	99.19 87.11	5.568 4.572	4.260 3.864	32.17 33.80	41.09 38.23
1967 3	1809.	643.	17.44	48.24	57.30	108.86	5.665	3.766	33.57	46.62
1967 4 1967 5	1615. 1510.	985. 965.	16.73 20.63	42.21 43.71	56.11 55.19	98.55 100.87	4.950 5. 036	3.798 3.865	33.39 33.30	43.09 41.32
1957 6	1481.	895.	20.97	45.55	58.71	103.95	4.971	3.736	32.07	41.45
1967 7	1348.	647.	21.22	50.82	59.48	112.50	4.595	J.331	33.22	45.98
1967 8 1967 9	1509. 1664.	529. 469.	19.63	35.06 55.18	59.71 59.01	120.01 120.51	5.364 5.293	3.275 3.248	33.11 33.39	47.76 45.87
1967 10	1847.	921.	17.10	44.53	57.79	102.26	5.613	4.162	31.74	39.47
1967 11	1621.	861.	16.35	50.79	55.11	113.79	5.648	3.615	31.41	46.57
1967 12	1739.	861.	16.17	53.11	55.33	118.09	5.573	3.832	31.64	48.38
1968 1 1968 . Z	1813. 1558.	801. 579.	17.08 17.97	56.86	55.40	125.11	5.653	3.508	32.04	48.55
1964 3	1671.	392.	17.62	53.60 65.22	55.46 55.73	110.09 137.93	5.031 5.342	3.011 2.955	31.93 34.73	46.79 53.12
1968 4	1765.	554.	17.54	57.24	55.21	124.16	5.412	3.057	33.86	51.21
1968 5 1968 6	1773. 1434.	587. 569.	17.40 15.79	57.35 56.60	55.28 55.09	124.66 123.19	5.413 4.836	3.202 3.221	33.00 33.00	50.27 48.91
1968 7	1500.	498.	19.69	55.32	55.39	120.36	5.195	3.109	32.84	48.16
1968 8 1968 9	1540. 1674.	350. 333.	15.47 16.27	60.49 60.11	56.11 55.69	129.35	5.240 5.349	2.971	33.55	49.77 49.33
1964 10	1979.	913.	15.76	45.28	55.66	129.46 104.34	6.122	2.985 4.104	35.60 32.47	41.13
1968 11	1003.	1096.	15.35	43.53	54.29	101.72	5.631	4.161	31.77	44.32
1969 12	1819.	1106.	17.09	45.33	54.16	104.99	5.710	4.162	31.69	44.06
1959 1 1969 2	1837. 1632.	1274. 1098.	17.86	39.95 34.85	54.39 54.41	95.66 85.35	5.810 5.148	4.398 3.912	31.51 32.10	38.33 35.87
1969 3	1755.	910.	14.52	46.57	53.98	105.11	5.702	3.866	32.10	44.09
1969 4	1771.	1246.	19.21	33.35	53.80	82.39	5.476	4.247	33.39	36.75
1969 5 1969 6	1607. 1512.	1410. 1533.	20.51 22.2 3	28.49 20.85	54.42 56.97	74.42 60.91	5.235 5.087	4.645 4.963	32.18 31.46	33.10 27.69
1969 7	1529.	1442.	22.99	22.46	57.80	63.16	5.142	6.730	34.63	29.97
1959 8	1474.	1250.	23.73	29.34	58.28	75.57	4.838	4.542	34.58	32.41
1969 9 1969 10	1699. 1966.	1177. 1536.	22.83 22.39	30.91 23.45	59.78 60.63	78.96 66.09	5.309 5.726	4.474 5.210	34.57 32.74	33.22 27.81
1969 11	1577.	1736.	22.47	21.21	59.45	63.02	4.672	5.248	32.80	27.35
1969 12	1729.	1633.	23.40	25.19	60.70	69.64	5.543	5.121	32.86	29.30
1970 1 1970 Z	16*6. 1441.	1613. 1458.	23.62 24.25	27.01 21.59	62.29 61.74	73.26 61.90	5.207 4.562	4.979 4.529	32.47 31.92	27.78 24.54
1970 3	1663.	1220.	22.25	35.23	61.11	66.01	5.262	4.374	31.16	31.86
1970 4	1701.	1172.	20.60	35.48	59.63	46.64	5.394	4.122	30.52	31.99
1978 5 1978 6	1506. 1531.	1476. 1673.	20.1 5 20.5 5	25.44 17.46	59.44 59.17	69.49 55.95	4.965 5.132	4.736 5.104	30.39 30.47	27.00 22.00
1970 7	1539.	1455.	21.35	22.17	99.40	64.12	5.190	4.736	30.50	26.19
1970 8	1567.	1430.	18.87	24.08	54.60	67.68	5.150	4.611	23.63	26.80
1970 9 1970 10	1804. 1997.	1355.	17.26 15.20	26.21 18.29	56.1 5 54.29	71.49 58.38	5.750 6.130	4.750 5.498	28.84 28.53	30.2 5 23.92
1970 11	1909.	1711.	13.33	24.59	51.36	70.07	5.901	5.164	27.72	32.45
1970 12	2133.	. 1762.	13.30	26.00	49.39	72.71	6.543	5.260	29.53	33.52

Table A6

MYERS STRUCTURAL MODEL ACTUAL AND ESTIMATED ENDOGENOUS VARIABLES

				(2)					
		*** 008	PC	EST PC	PB	EST PO	QPS	EST 0PS	QC	EST QC
HTHOM PASY	200	EST Q00	••		-					

	7.954	6.408	22.52	39.61	72.36	110.57	993.	893.	2698. 2390.	2230. 23 0 2.
1965 1 1965 2	7.046	6.609	22.15	27.92	71.81	45.70	860.	863. 823.	2747.	2086.
1965 2 1965 3	8.098	5.994	22.46	39.56	71.93	110.95	1 0 76. 996.	843.	2.93.	2145.
1965 4	7.336	6.148	23.56	35.47	71.45 72.08	102.10 117.30	859.	811.	2503.	2020.
1965 5	7.370	5.714	25.06	42.50 41.09	76.20	113.97	890.	814.	2680 .	2070.
1965 6	7.872	5.921	25.93 25.41	46.90	76.95	120.96	621.	719.	2077.	1896.
1965 7	7.911 8.043	5.418 4.955	25.55	54.29	76.09	143.03	864.	654.	2769. 2469.	1736. 1506.
1965 • 1965 •	8.326	6.274	25.47	61.76	75.86	160.19	945. 936.	553. 736.	2550.	1795.
1965 10	8.204	5.110	24.76	55.74	75.09 74.32	146.1 9 152. 0 4	932.	669.	2012.	1554.
1965 11 1965 12	8.031 6.109	4.419 3.912	24.36 24.36	57.68 63.28	74.41	163.79	878.	603.	2628.	1377.
1707	••••									1519.
1966 1	A.470	4.313	24.54	63.99	74.77	164.47	850. 805.	610. 585.	2336. 2597.	1627.
1966 2	7.489	4.614	25.46	51.62	75.36	138.12	1002.	583.	2026.	1528.
1966 3	8.147	4.331	25.53	59.61	76.61 76.80	155.56 136.92	895.	642.	2634.	1742.
1966	7.651	4.934	25.32 24.32	51.35 55.17	75.40	144.89	876.	653.	2793.	1724. 1492.
1966 5	A.055 A.542	4.878 3.630	21.48	47.85	74.58	128.46	916.	743. 748.	2953. 2712.	2156.
1966 6 1966 7	7.917	6.487	23.46	44.14	74.05	119.39	801. 929.	821.	3023.	2397.
1966	8.807	6.762	23.92	40.18	73.81 73.88	110.42 106.69	997.	810.	2369.	2454.
1966 9	4.506	6.913	23.97	36.25 40.63	73.54	111.64	1027.	915.	2496.	2473.
1965 10	0.463	5.960 6.621	23.32	39.05	72.95	109.22	1076.	907.	2886.	2355. 2344.
1956 11 1966 12	A.343 B.295	6.554	22.40	39.06	72.63	109.37	1095.	951.	2160.	2344.
1,00									3006.	2105.
1967 1	8.722	5.907	23.16	50.35	72.19	134.20	1103.	844. 766.	2069.	2001.
1967 2	7.767	5.612	22.76	43.35	72.56	120.00	966. 1124.	752.	2135.	1825.
1967 3	8.512	5.113	22.53	53.40	71.91 71.21	141.78 138.36	963.	754.	2137.	1791.
1967 4	A. 031	5.013	22.58	51.52 56.17	70.67	148.16	1001.	772.	3020.	1723.
1967 5	8.878	4.819 4.704	23.27 23.82	57.31	72.24	158.71	959.	743.	2989.	1643. 1563.
1957 6 1967 7	8.787 8.055	4.365	24.52	60.94	72.19	158.91	915.	663.	2740. 2393.	1585.
1967 7 1967 8	8.720	4.413	25.18	63.32	72.46	163.65	1069. 1056.	653. 648.	2449.	1665.
1967 9	8.255	4.639	25.29	60.60	73.44	158.19 146.52	1121.	831.	2999.	1935.
1967 10	8.642	5.316	24.55	55.75	73.19 73.01	152.94	1129.	763.	2826.	1689.
1967 11	8.084	4.697	24.87	54.08 60.20	72.84	157.76	1115.	767.	2773.	1619.
1967 12	7.962	4.498	23.66	94.24		••••				
1968 1 1968 2 1965 3	8.979 8.151 8.060	4.019 3.704	23.95 24.31 24.68	65.18 60.19 69.15	72.77 72.63 72.30	166.52 158.64 177.58	1172. 1008. 1071.	718. 603. 592.	3117. 2816. 2787.	1597. 1448. 1336.
1965 4	8.163		24.45	64.08	71.89	166.76	1096.	613.	2811.	1432.
1968 5 1969 6	8.939	4.036 4.044	24.24 24.24	66.83 66.48	72.15 71.79	172.54 171.82	1101. 984.	643. 647.	3069. 2302.	145 6. 1462.
1966 7	8.454	4.250	25.00	64.17	71.77	166.56	1045.	625.	3065.	1538.
1959 8	8.933	4.261	25.35	66.94	72.27	172.35	1055.	598.	3072.	1543.
1968 9	8.559		25.17	63.63	72.26	165.54	1076.	602.	2962.	1663.
1966 10	9.502	5.715	24.99	54.99	71.85	145.43	1235.	828.	3504.	2081.
1968 11 1968 12	8.276 8.149		25.11 25.49	49.59 51.11	71.72 7 1.22	134.05 137.54	1137. 1154.	840. 841.	2367. 2843.	2130. 2071.
1,00	0.147	,,	.,,,,	,	*****	13.174	*****	042.		
1959 1	9.192	6.436	25.22	48.09	72.60	129.84	1175.	686.	3206.	2341.
1969 2	8.055	6.146	24.98	41.33	72.23	116.23	1042.	792.	2796.	2237.
1969 3	8.195		25.94	50.56	71.58	135.35	1155.	783.	2850.	2092.
1969 4	A.224 A.305		27.09	42.26	73.34	117.57 112.23	1114.	861.	2659.	2297. 2516.
1969 5 196 3 6	8.205		29.34 29.82	40.16 32.56	74.76 78.37	94.87	1062. 1033.	942. 1006.	2876. 2847.	2809.
1969 7	8.615	7.790	27.59	32.90	79.33	95.41	1045.	961.	3105.	2847.
1959	8.525		26.78	37.85	77.78	106.41	964.	924.	2167.	2763.
1969 9	9.111		25.41	36.52	77.03	104.05	1081.	911.	3152.	2792.
1959 1 8 1959 11	9.745	8.101 8.059	24.49 24.16	34.50 29.82	73.34 73.95	98.71 89.48	1167. 994.	1062. 1071.	3362. 2309.	2970. 2957.
1969 12	8.435		24.36	32.13	73.80	94.53	1140.	1046.	3076.	2868.
1970 1	9.161		24.50	35.63	73.98	101.32	1054.	1017.	3194.	2718.
1970 2 1970 3	4.013		25.25	28.82	73.43	87.76	933.	926.	2789.	2802. 2523.
1970 3 1970 4	6.714	6.248	26.65 26.30	40.89 45.28	74.62 74.55	114.30 124.63	1077. 1105.	896. 844.	2966. 3015.	2302.
1970 5	A. 407		25.38	37.96	73.65	106.19	1014.	971.	2924.	2669.
1970 6	9.806	7.134	25.81	30.81	72.86	92.14	1053.	1047.	3350.	2913.
1970 7	4.502	7.657	23.24	34.23	74.21	99.96	1066.	973.	3051.	2829.
1970 8	8.434	7.855	25.54	34.95	73.62	101.20	1065.	989.	2918.	2905.
1970 9 1970 10	9.076 9.285	7.965 4.347	25.07 24.61	33.69 31.46	72.25 71.25	98.78 93.18	1155. 1263.	978. 1131.	J144. 3216.	29-8. 3043.
1970 11	8.223		21.26	34.05	70.83	100.44	1203.	1065.	2674.	2799.
1970 12	8.967	7.259	22.77	36.22	69.64	105.46	1353.	1046.	3119.	2695.

Table A7

WVERS STRUCTURAL MODEL: Forecasting Performance

	9	£	å	040	PC4	380	၁	88	SAD	90
COST DERIVED LOSS										
30°0	13.40	.35	64	10.	50.	1 O C	.37	08	2.16	41.18
Z # 0.12	74.41	1.56	2,25	.03	. 23	11.	1.60	3.78	12, 91	67.61
Z H 0.32	908.59	10.13	17.45	41.	1.54	5.50	10.64	5 X 7 X	154.59	94.476
	1122.79	11.75	20.60	•16	1.78	.50	12.42	36.67	190.61	1224.04
N # 1.00 (H.S.E.)	451264.76	578.02	1602.72	1.74	91.39	7.91	668.79	3809.67	69630.54	825677.04
INCUDALIIY MEASURES										
U 1	.8295	. 9525	.9675	.7553	• 906•	.6230	.9731	.9860	.7572	. 8146
C 0	4.3066	17.9304	27.1865	2.9556	9.6623	4.4921	34.9425	58.0806	2.9543	4.2393
TURNING POINT ERRORS	39.	38.	34.	37.	37.	31.	31.	33.	37.	32.
AVERAGE ABSOLUTE ERROR	565.00	20.29	36.44	1.14	7.90	2.50	22.96	55.72	227.50	777.62
AVERAGE RELATIVE ERPOR	34.68	105.75	62.74	21.82	23,70	29.84	93.60	76.11	21.82	26.92
THIRD ABSOLUTE MOMENT	•036126.17	18777.51 101652.30	101652.30	3.07	1223.64	28.22	22001.18	293731.09*	293731.09*525498.87*393108.60	393108.60
FOURTH HOMENT	*969380.15	655335.226166430.19	166430.19	5.86	17852.48	107.76	773395.13*	281732.82*	107.76 773335.13*281732.82*537909.75*966292.95	966292.95
CORRELATION	. 2894	.0173	.1741	.3848	.4236	.2913	0746	1577	.4771	.3420
SLOPE	.1417	.0041	.0349	.2727	.1257	.1095	0092	0114	.3553	.1218
BIAS (AVERAGE ERROR)	554.8065	-20.0416	-36.3481	1.1283	-6.1257	2.5025	-22.9574	-55.7235	225.3680	773.1456

NO OF OBSERVATIONS IN THE CALCULATION OF SAR SUBROUTINE * 72

Table A8

WYERS STAGE I FUNATIONS

ACTUAL AND ESTIMATED ENDOUENOUS VANGABLES

(1)

						(1)					
YEAR	MONTH	QH	EST UH	PH	EST PH	· ·	Eşt PP	4-6	43 7 050	€c ⁱ	ENT PCH
1965 1965 1965 1965 1965 1965 1965 1965	1 2 3 4 5 6 7 8 9 10 11	1675, 1439, 1756, 1388, 1327, 1340, 1302, 1404, 1535, 1411,	1d79, 1543, 1644, 1644, 1644, 1646, 1447, 1447, 1462, 1774, 1564,	19190 16181 16176 1714 1718 1718 25179 25179 25179 25179 25179 25179 25179 25179 25179 25179 25179	17.25 19.11 19.05 17.89 17.99 19.50 20.65 21.72 22.33 21.75 20.54	78 72,19 72,19 72,14 72,44 72,44 71,44 61,44 61,44 62,57 65	47.88 50:462 49:462 49:06 52:54 54:54 57:29 58:43 59:34	5,132 4,744 5,752 7,135 4,124 4,174 4,417 4,417 4,417	941206 91206 91206 91207 91207 9120 9127 9127 9127 9127 9127 9127	34 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4	30:05 34:23 34:40 34:44 34:60 34:64 34:50 34:50 34:50 34:50
1900 1900 1900 1900 1900 1900 1900 1900	1 2 3 4 5 6 7 8 9 10 11 12	1330, 1285, 1603, 1493, 1493, 1369, 1203, 1502, 1658, 1755,	1949. 1363. 1443. 14/3. 14/3. 13/37. 13/37. 13/37. 13/37. 13/37. 13/37. 13/37.	26.70 20,38 23,16 21,16 21,19 32,39 23,58 24,11 21,67 20,31 10,76	23.75 25.50 26.13 24.95 23.04 24.39 24.11 24.40 24.62 23.31 21.36	69, 42 69, 46 64, 98 63, 41 63, 95 64, 34 64, 44 65, 23 60, 65	59.24 61.69 62.99 61.39 58.97 59.66 61.58 63.39 60.59 53.55 53.33	4,348 4,127 5,136 4,359 4,757 4,960 4,713 5,198 5,198 5,441 5,832	\$ 125 4 210 4 1723 4 1743 4 1743 4 1743 4 1743 5 1275 5 1275	39 i 03 d 6 i 39 d 6 i 30 d 6	34:31 34:32 34:02 34:02 34:23 34:01 39:59 29:26 29:26
1967 1967 1967 1967 1967 1967 1967 1967	1 2 3 4 5 6 7 8 9 10 11 12	1774, 1561, 1601, 1510, 1510, 1481, 1666, 1647, 1521, 1739,	18 8, 15 97, 16 73, 16 73, 17 74, 16 72, 15 74, 15 14, 16 13, 16 13,	18,32 18,28 17,44 16,73 20,03 20,03 21,22 19,83 18,35 16,35	19.75 20.32 20.37 17.80 17.28 17.13 17.13 18.24 18.34 15.63	98:85 74:18 74:18 74:19 76:19 76:49 76:49 76:49 76:41 76:41 76:41	90.87 91.98 91.98 47.12 45.74 47.48 48.54 91.40 95.48 44.94	3,964 4,472 3,959 4,979 4,973 4,973 5,444 5,203 5,444 5,273	54775 47772 51722 51722 51372 51372 51372 51372 51372 51372 51373	32 118 33 160 43 157 43 138 42 102 43 122 43 112 43 114 41 143 41 143	30:60 34:10 34:10 34:17 34:00 34:50 34:12 24:42 24:42 24:50 24:50
1900 1908 1908 1908 1908 1908 1908 1908	1 2 3 4 5 6 7 6 9 10 11 12	18174 10745 10745 1773 1773 1070 1070 1070 1010	1976 1 1508 1 1508 1 1600 1 16 20 1 27 02 1 27 02 1 27 07 1 14 2 1 20 1 20 1 20 1 20 1 20 1 20 1 20 1	17 19 2 17 15 4 17 15 4 18 18 18 18 18 18 18 18 18 18 18 18 18 1	15.73 17.94 19.42 15.13 17.09 19.44 16.00 17.71	50 : 48 50 : 48 50 : 46 50 : 173 50 : 123 50 : 125 50 : 31 50 : 50 50 : 60 50	44.20 47.60 47.07 44.27 44.27 47.34 50.36 50.05 47.16	3,833 2,834 2,442 3,446 3,149 6,127 3,710	9 9 9 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4	32 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	2/171 29:46 20:70 2/101 2/101 2/106 2/106 20:00 20 20 20 20 20 20 20 20 20 20 20 20 2
1969 1969 1969 1969 1969 1969 1769 1969	1 2 3 4 5 6 7 8 9 10 11	1637, 1632, 1755, 1761, 1697, 1697, 1697, 1697, 1697, 1697, 1697, 1697, 1728,	1876. 1573, 1663, 1733, 1676. 1501, 1501, 1618. 1618.	17.86 18.37 18.52 18.52 20.51 22.23 22.73 22.73 22.43 22.47 23.47	16.61 19.56 19.46 16.81 16.89 18.68 19.48 19.48 17.63	54,39 54,41 55,98 55,98 54,42 54,28 54,28 54,28 54,28 54,38 54,38 54,38 54,38	4b. 06 4v. d6 70.02 40.57 40.53 4v. 98 4v. 31 72.73 72.73 73.05 4d.91 73.79	5:816 5:148 5:782 5:495 5:237 5:142 4:131 5:170 4:372 4:372 5:393	9	31 E 5 8 32 <u>1</u> 1 2 4 32 <u>1</u> 1 3 4 32 <u>1</u> 1 4 9 33 <u>1</u> 4 9 4 34 <u>1</u> 5 9 34 <u>1</u> 5 9 32 <u>1</u> 9 9 32 <u>1</u> 9 9	2/1:51 2/1:51 2/1:40 2/1:40 2/1:51 2/1:51 2/1:51 2/1:51 2/1:51 2/1:51 2/1:51
1978 1978 1979 1979 1977 1977 1978 1978	1 2 3 4 7 6 7 8 9 10 11 12	1044, 1441, 1763, 1761, 1513, 1514, 1597, 1797, 1797, 1798, 2133,	1000, 1477, 1617, 1644, 1740, 1017, 1617, 1617, 1617, 1814, 2117,	23.62 24.25 24.25 24.48 26.15 24.55 21.35 17.67 17.20 13.33 13.38	19.74 21.90 22.33 19.72 17.71 18.72 18.39 19.19 16.39 16.49 17.21	67,79 61,74 91,11 31,63 31,44 31,17 31,48 32,68 36,13 34,79 31,38 45,39	70.01 24.24 24.21 20.39 46.97 46.24 49.61 49.61 49.93 42.96 48.26	5.477 4.762 7.404 4.663 5.190 5.190 5.170 5.170 5.170 5.170 5.170	\$40.000 \$41.000 \$1.000	JZ 14/ JI 19/ JI 19/ JO	24:50 24:90 24:02 24:02 24:02 24:02 24:02 24:02 24:00 24:00 24:00

Table A9

MYERS STAGE ! EQUATIONS VANIABLES

(2)

						(2)					
YEAR P	10NTH	949	6\$1 480	PC	EST PC	ķe.	eżi ne	448	681 062	yc	eşt oç
1965	1 2	7,954 7,048	e, 329 7, 422	22,52	25.70	/2,36	68,84	••3·	1060.	2678.	2413.
1965	2 3	7,048 0,078	7,422 7,486	22,52 22,15 22,46	20.70	/1;61	68,84 68,29 66,94	38A.	1869.	5255 a	2474
1965	4	7.336	7,027	23,56	20,18 21,59	/1:45	70.10	1376	1000.	2747 2493	2/13.
1965	5	7.370	7,864 7,756	25.76	22.87	72,08	72.79		978.	2503.	2067
1965	6	7,572	7,756	25.93	24,25	75,70	/6.13	340.	772.	2600	2946
1965	á	7,811	162	29.41 25.55	24.45 24.7c	76.19	75.16 74.95	421.	909. 922.	26/7 2709 2809	2/08. 2907.
1505	9	6,326	E./05	25.47	22,13	79,46	60,95	34A.	904.	2009	2761
1965	10 11	8,2;8 8,031	6.714 7.661	24.76	22,65	/*,,,	64.10	134	991.	2070-	3041.
1965	12	8,100	4.121	24.36	23,5 ₀ 23,22	71 1 6 3 7 1 1 4 5 7 1 1 4 5 7 1 1 4 5 7 1 1 4 5 7 1 1 4 7 1 7 1 7 1 7 1 7 1 7 1 7 1 7 1	/2.16 /2 ₁ 02	742, 7/At	1001.	3844	2916. 2918.
1966 1966	1 2	6.470 7,449	£.557	24.54	24.15	74.77	74.47	350,	941.	39761	5,30,
1966	3	8.147	7,774 6,264	27,46	23,19 23,62	79,36 75,61	72,88 72,83	107, 1102,	920. 917	2597g 2046g	2936,
1966	4	7.651		20.53	25,50	76.Pg	77.03		871.	26342	2055
1900	5	8 555 8 642	7. 743 1. U27	24.32	26.36	75.48 74.58	79.05	494.	92 4 919	3773 2053	2/23
1966	ž	7,917	0,115	23,46	20.46	/4. 15	79.64 70.11	914; 761.	891.	2712	2/3/.
1966	8	7ر8.6	7.261	23.92	26,62	/3,21 /3,80	/9.11 74.72	120	922.	3043	2175.
1966	10	9.636		23.97 23.32	24.49	/3 AB	74.72	497,	910,	3043 2999 2896	2748.
1966	ii	6.343	r,104	22.75	24,21	/2, 45	71,51 74,31	102' 102' 10(1	1001, 1029,	2806	3114
1966	12	8,295	1,223	22,40	23,45	15,49	74,15	1995	1071.	\$9.40°	2979
1967	1 2	7,772	N. 925 C. 048	23.16	22.65 22.67	/2.19 /2,56 /1,71 /1,21	72,54	11231	1882.	30961	3466,
1967	3	4.532	",>63	22,53	22.27	/1.71	71.46	705; 8164;	1034,	2699	2901, 2956,
1967	4	0,:31	0,326	22,58	72.49	/1,21	/1.49	403,	1012.	2945 2747	2954.
1967 1967	5	8,870 5,787	1,417	23,27	24.22	/0.0/	/5.63	1 184	1850.	30402	2907;
1967	ž	6,797 8.256	h. 435 1. 430	23,82 24,52	24,45	72,29 /2,19	76,31 74,75	140	1829. 1808.	2749	5 4 2 8 *
1967	8	8,256 8,720	r./56	25,18	23,47	/2,46	72,92	1949.	1027.	2740± 2993±	3754
1967 1967	,,	8,255	6.432	25.29	22,37	73,44 73,19	/0.70	1056.	1007.	2040	3497.
1967	10 11	3,642 8,094	H. 176 P. 274	24.55 24.:7	22.92 25.41	23,11	72.34 73.00	1171,	1151,	5050	3100
1967	12	7,962	8,385	23,56	85.14	72,44	71.43	1115,	1151.	27/3	2705
						·				•	
4049		• 0-•									
1968	ž	A,979	7.046	23.95	21:39	12.128	69.89	1173:	1872:	3117	3120
1968	3	8.040	+ #45 + 470	23,95 24,31 24,68 24,45 24,24 24,24	21.02	/2:77 7:169 7:130 /1:49 /:15 /:179 /1:77 /:27	67.68 67.96 69.74	1271	1053	2747	3,90
1948	4	8,919	*.470	24,45	21.75	/1,19	69.74	1736,	1024,	2747 2011	2791
1968	6	8,125	1 /98 1 /37	24,24	71,06 22,74	/; • 15	/0.05 /1.51	1101	1074,	3099 2042	3449. 3437.
1968	7	8,534	r.>50	23.00	23.33	11.77	/2,95 /1,27	1015	1060. 1022.	4007.	2 4 4 4 .
1948	9	6,930	7.75g H. V27 7.169 9.4n2	25,35	22.43	71.27	/1.27	1:34.	1021.		3.22.
1968	10	8,559 9,5,2	9.402	25.17 24.69	27 65 27 47		66.70 66.71	1279	1023.	3,05.	3402
1966	11	6.236	7.207	25.11 25.47	22.25	/1,45 /1,72	70.37	1127	1134.	1304 2007	3v42.
1666	12	6,149	F. 623	25,49	21,19	71,72	59,25	1154,	1150.	2843	3449.
1969	1	9,112 3,258 4,176 8,224	6.78	25.72 24.96 25.94 27.09	21.07	72,60	7:.73 66,51	11/5.	1174.	370Ag 2/46g	3166.
1769	3	4,176	€./€.	25.94	21.03	/1.5#	07.19	1155.	1077	4620	3000.
1969	5	8,224	C.44:	27.09	21./2	/2,34 /4,76	71.42	1114,	1054.	2020	3 v " q . 2 + > 9 .
1969	6	0,3,5 0,2,5	4.571 5.433	29,34	25,47 24,67	/4,/8	/>,62 /r.61	1047.	10°4. 1067.	۷7/0.	3,00.
1949	7	1.015		27.59	22.01	/n 17 /9 33	73,39	1045,	1042	2047 3045	3443.
1649	A Q	6,575	5,021	25.79	23,17	75 33 77 78	73.79	194	1051.	240/-	31/3.
1949	10	9,111 9,7~8	, 235	25.41 24,49	21.50 21.66	17,03	/(,>1	1301.	1077.	\$122	3401,
1969	īi	4.044	7.13:	24,16	22,45	/3.95	71.43	1137,	1131. 1144.	3808 73654	3409. 3469.
1569	17	u, 3 (5	1,524	24,36	72,97	/3 ₂ 4 g	73,16	1110,	1149.	J0/41	3445
1970	1 2	8:118	9,326	24.5u 20.25	20.84	73,98	/1:30 /1:31	1364,	1134	3174. 2789	3631
1970	3	8.416	f 323 f #39	29,29	21.19	72,43	/1,/1 /1,23	113	45 4 ,	5/64	2465
1970	4	0,714		24,36	23.72	74,62 74,55	69,49	11/7.	1055.	3012	3,16. 3,70.
1970	5	4.1.7	* . * <i>!</i> ?	29.36	2: 77	/3,75	/6.54	1114	1040	3070	3127.
1 + 70	,	8,3;6 9,314		27,11 26,24	21.75	//,56	73,60	8633	1077	30>0	30/3.
1970	,	4,414	1118	25,64	20.37	/3, 45 //, 66 /4, 21 /2, 82 /3, 25	69,29 67,84	1:34:	1047	2071	3303:
1475	•	7,376	7.731	25.57	17.70		64,40	2114,	1004.	3031 271 A 3144	3158.
1970	10 11	V 245	v, 534 c, 757	24,61	20.31	11.73	40,00	1253.	1004.		33/4.
1970	13	8, 967	F://6	23,76 22,77	23.20	/3 A3	69.14 64,52	1417	1100	2A/41 3149	3,36
-	-	•	• •	1		, 100	, **	•	45°T (414.8	- 4 -4,

Table AlO MYLKS STAGE | EDUATIONS; Forecasting Performance

	Š.	T.	ā .	Geo	g.	a e o	ဝ	£.	a a S	· છ	
COST DEMIVED LOSS		,									
4 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 44 6 10 0 6 10 0 7 10 0	 101 104	0 4 8 8 4 8 8 6 6	963	. 0 . 0 . 0 . 0 . 0 . 0 . 0 . 0 . 0 . 0	 600	-4 4 4 0 0 4 4 4 8	0 6 6	0 0 0 0	18.20 18.20	
H 1,60 (M.S.E.)	230 40 511	5,70	57.15	11	33. 4 9	100	9 7 9	10,54	3717,72	23,75	
INFCUALITY MEASUPES -								٠			
U 1	,5522	9902	,8154	1905.	,8426	.303/	18055	.7144	9774	13477	
	,9/31	1;7812	4,8407	.7427	9.9711	15719	4,2206	\$.0547	.0046	: 6682	
TURLING POINT ERADRS	26,	24;	21.	26.	32.	22.	31.5	* 0*	25,	5≰!	
AVELAGE ABSOLUTE ERMUR	166.54	2.01	7.02	,24	5,34	62.	4167	. S.	99,09	\$15.29	
AVENÃGE PELATIVE EPROP	8 11.	9.89	12,04	5,43	16,22	3,53	10,59	3,57	4.4	4,03	
THIND Adsounte Honeut	\$675352.22	18.01	510.67	• 6	260,46	20.	41,33	51.90	140>36,U1A	340239,u14419497,19	
FOCATE EGGENT	+1276t6 <u>,</u> 39	65,97	4066.97	.0.	2131.91	•	1.Vn. 79	273,084	108905.479	273,08*16893g,<74935391,62	
CONSTELATION	#600#	\$679.	. 8392	. 7653	37978	.7936	10420	.4623	4447	:4131	
SLnre	,7911	17725	,7262	1.0003	14741	. 8549	10164	.2764	1,1244	1961	
BIA'S (AVERAGE ERPOR)	•45,6142	.5738	7.0192	1,00.	5,3428	1723	2,2589	1.5601	6/6212	-83:4462	

NO OF DUSERVATIONS IN THE CALCULATION OF SAM SUBROUTINE . 72

Table All Exogenous variables used in the laternesser and hassler model

YEAR	MONTH	500	0000	92)	wł	t
1965	1	25.30	80	15.40	2.43	2102.
1965 1965	3	25.3J 25.3J	60	15.33 15.33	2.43	2152.
1765	į	25.70	70	19.55	2.45 2.45	2162. 2184.
1965	5	25.20	70	14.53	2.40	2154.
1765 1965	6 7	25.20 26.10	70 1.60	16.13	2.66	2154.
1965		26.10	1.60	13.33	2.42	2244. 2244.
1965	9	26. tu	1.60	13. 11	2.+3	2244.
1765		26.)u 26.)0	.10	14.53 14.53	2.42	2274.
1 165		26.30	.10	14.50	2.47	2274. 2274.
1906 1966	î 2	26.50 26.50	40	13.52	2.44	2255. 2255.
1966	3	26.50	40	13.50	2.51	2255.
1966	2	26.70	.20	14.23	2.33	2293.
1966 1966	5	26.70 26.7 0	.20	14.23	2.53	2217. 2217.
1 366	7	28.30	1.30	14.10	2.52	23)0.
1366	8	24.10	1.30	14.10	2.43	23u0.
1766		28.J0 27.S0	1.30	14.10 16.20	2.51	2310. 2319.
1706	11	27.50 27.3ú	75	10.21	2.54	2317.
1966	12	27.50	70	16.23	2.57	2319.
1967 1967	1 2	27.20 27.20	10 10	16.23 16.23	2.50 2.61	2349. 2344.
1967	3	27.20 27.70	10	15.23	2.63	23.5.
1967 1967	5	27.70	.50 .50	19.30 15.30	2.65 2.65	2357. 2357.
1967	6	27.70 27.70	.50	15.3)	2.6+	2357.
1967 1967	7	27.30	.20	15.50	2.63	2352.
1967	ġ	27.10 27.10 27.10	.20 .20	13.50 15.50	2.62 2.63	5365.
1967	10	26.10	-1.00	15.70	2.6+	2377.
1967 1967	11 12	26.10 26.30	-1.03 -1.00	15.33 16.30	2.67	2377.
270.	••	20.70	-1.00	10.70	2.53	2377.
1968 1968 1968	1 2 3	27.40 27.30 27.40	.90 .90 .98	16.36 16.33 16.33	2.76 2.75 2.75	2411. 2411. 2411.
1968	•	27.70	10	16.10	2.76	2436.
1968	5	27.70 27.70	10 10	15.18	2.50	2435.
1968	7	29.20	1.50	15.10 15.38	2.60 2.73	2436. 2427.
1968	6	29.20	1.50	16.)u	2.77	2427.
1968	10	20.30 29.20	1.50	15.33	2.90	2427. 2432.
1905	11	28.10	90	17.50	2.85	2432.
1 46 8	12	28.30	90	17.63	2.67	2432.
1969 1969	1 2	23.00 25.00	30 30	17.00 17.00	2.91 2.91	2431. 2431.
1969	3	28.30	30	17.33	2.33	2431.
1959	5	27.40 27.40	63	15.33	2.34	2433.
1969	6	27.40	60 60	15.33 15.33	2.35 2.94	2433. 2433.
1969	7	29.50	1.90	15.42	2.37	2457.
1969	8	29.10 29.10	1.90	15.63	2.33	24,7.
1469	10	29.10	20	15. +J 15. 5J	2.95 2.97	2+57. 2458.
1969		29.10	20	15.51	3.00	2.54.
1.164	15	29.10	20	10.37	3.0+	2454.
1778	1 2	79.10 29.10	B. 40	15.51	3.34	2464. 2464.
1970 1370	3	29.10	0.03	15.43	3.10	2464.
1970	ì	29.10	50 50	17.30 15.5J	J.12 J.16	2435. 2455.
1970	6	24.10	50	15.53	1.15	2495.
1970	,	29./0 23.78	1.10	16.17	3.16	2430.
1970	ij	23.70	1.10	16. JO 15. JO	3.13 3.20	2433. 2430.
1970	10	24.20	51	1 4. 10	3.20	2468.
1978	11	29.70 29.20	50	14.10	3.24	2468.
• • •	**	67.CV	50	11.11	3.27	2466.

Table Al2

TRIERWEILER ANN MASSLER FODEL ACTUAL AND ESTIMATED ESTOCIETUS VARIABLES

YEAT	HOUTH	PBC	EST 20C	PHSI	EST PHS1	PBSZ	EST 2052	PPS	EST PPS	288	EST POR	PPR	EST PPR
1955 1955 1963 1963 1965	1 2 3 4	37.14 36.38 36.73 38.71 41.36	37.43 37.43 37.10 34.53 15.40	22.98 22.53 23.17 24.58 25.08	23.17 21.17 23.00 23.93 23.00	22.98 22.53 23.17 24.38 26.00	22.09 22.03 22.03 23.76 22.70	16.44 17.25 17.35 17.91 20.57	15.51 15.51 15.50 17.09 17.00	78.60 79.63 78.60 88.33	85.63 85.63 85.63 84.87	56.88 56.88 56.30 59.70 59.70	61.20 61.20 61.20 63.77 63.77
1965 1959	ŕ	43.6J 60.75	31.66 40.27	26.49 26.45	24.42 25.13	26.69 26.65	23.83	23.70	17.11	30.50 34.20	89.73	59./0 09./8	63.77 69.97
1965 1965 1965	4 9 13	40.11 37.21 38.74	40.33 40.14 421	26.28 25.19 25.33	25.81 25.84 25.43	26.26 26.19 25. JJ	26.02 25.83 25.21	23.04 23.02 23.27	22.71 22.57 23.24	84.28 84.2J 82.90	83.73 83.73 84.47	69.70 69.70 70.70	69.97 63.97 76.u1
1965	11	34, 59 34, 29	34.35 34.37	24.93 25.30	24.64 24.41	24.93	25.03	24.29 25.46	23.22	12.90 12.90	88.47	70.70 70.70	76.01 76.01
1965 1955 1955	2	40.74 41.53 42.74	40.87 40.37 40.52	25.91 27.16 29.25	25.74 25.74 25.56	25.91 27.16 28.25	25.66 25.66 25.54	28.61 24.59 24.93	21.26 21.26 21.23	84.60 84.60	84.53 88.53 88.53	78.10 78.10 78.10	74.98 74.98 74.98
1756	5	41.15 39.95	43.56 43.66	26.94 25.44	25.59 25.59	26. 94 25. 94	25.00 25.00	22.91 23.4u	24.84 24.34	63.50 15.50	88.66 88.66	72.40 72.40	67.17 67.17
1955 1956 1966	6 7 3	34.23 34.24 34.57	40.56 33.31 33.59	25.25 25.27 25.76	23.59 24.65 24.92	25.25 25.27 25.70	25.88 25.37 25.56	25.40 25.53 25.97	204 272 276	85.58 84.49 84.40	88.66 84.52 81.52	72.40 73.60 73.60	67.17 68.55 64.55
1906	, 10	34.53 57.90	33.44 49.15	25.54	24.74 24.74 25.23	25.54	2:.43 25.11	23.09	24.73	64.40 93.90	65.52 69.05	73.60 70.20	68.55 68.UZ
1966	11	17.39 17.45	39.59	23.92	25.46 24.79	23.92	24.98 24.79	20.63	22.30 22.76	53.90 63.93	83.05	78.20 70.23	68.02 68.02
1957 1957 1957	1	18.12 34.15 37.51	39.00 37.57	24.94 24. 32 21. 42	23.95 23.86	24.94 24.32 23.92	24.05 24.02	20.44	23.78 23.77 23.74	92.90	86.92 88.92 86.92	96.70 36.70	61.94 61.94 61.94
19n7 19n7	*	34. 27 39. 94	17.51 35.59 35.59	23.89	23.04 23.04 23.04	23.69	23.89 23.56 23.56	19.56 16.05 22.39	20.35	62.30 82.58 32.53	86.42	56.70 55.50 65.50	61.83 61.83
1997	7	46.44	35.42 35.42	25.45 26.15	23.13 24.50	25.45 26.18	2!.62 24.94	22.91 22.93	21.16 22.24	92.50 440	84.42 91.07	65.5 8 69.40	63.26
1947 1947 1957	3 9 13	42.09 42.40 41.11	39.05 39.92 48.34	26.63 26.63 25.98	24.67 24.58 25.56	26.57 26.63 25. 98	25.00 24.94 25.45	21.30 13.60 13.45	22.25 22.24 23.51	84.90 84.93 96.00	91.07 91.07 92.27	69.48 59.40 66.50	63.26 63. 26 66.61
1967 1957	11	41.00	39. 45 37. 69	25.34	25.29 25.11	25.34 25.48	25.27 25.14	17.74	20.57	35.00 05.00	92.27	56.50 66.50	66.61 66.61
1969 1954 1964	2	41.35 42.34 42.31	39.19 39.16 37.93	25.69 26.37 26.60	24.26 24.17 24.08	25.69 26.37 26.68	25.04 21.97 24.91	14.92 19.90 19.33	28.26 23.25 20.23	85.48 96.48 85.40	49.61 49.61 49.61	46.18 46.18 46.19	62.13 62.13 62.13 59.82
1954 1964 1968	5	42.21 42.30 42.70	39.42 39.16 39.16	26.50 26.30 25.39	24.43 24.25 24.25	26.50 26.30 26.39	21.89 21.77 24.77	19.39 19.37 20.94	23.37 23.34 20.34	85.60 85.63 86.68	91.30 91.30 91.30	56.48 56.48	59.82 59.82
1968	7	43.19	39.22	27.37	24.28 24.46	27.37 27.54	25.54	21.59	21.2 5 21.27	57.80 57.83	43.38		60.39
1953	10	42.35 42.10	71.09 73.74	27.27 27.45	24.14 25.36 25.41	27.27 27.05 27.36	25.39 25.59 21.34	23.15 18.41 13.01	21.23 23.34 20.39	87.8) 85.30 44.33	67.93 93.47 93.47	58.30 57.50 57.50	62.33 62.33
1953 196J	12	41.71 44.13	13.27	27.58 27.94	29.03	27.74	25.22	20.33	20.16	90.18	99.47	37.50 38.58	62.33
1959 1959 1953	2	44.79 44.15 45.40	57.46 14.46 57.20	27.50	25.33 25.15	27.50 28.41	25.91 25.78	20.84	21.36 21.14	€0.13 €0.13	89.81 87.81	58.50 68.50	58.82 58.82
1 45) 1 45 7	5	52.15	45.16 44.33	30.14	29.19 27.10	30.14 32.79	25.61	23.78	23.21 23.20 23.21	97.90 97.90 97.90	92.03 92.03 92.03	71.90 71.90 71.90	61.22 61.22 61.22
1951	7	53.15 49.11 -46.35	45.06 45.46 45.48	33.53 31.29 30.04	29.19 29.47 29.43	33.63 31.29 30.04	24.81 3!.25 11.50	25.73 26.47 27.18	25.34	131.03	90.75	77.60 77.60	64.U3
1953 1953 1753	9	49.93	43.39 43.24	23.46	27.56 27.54	24.66	31.31	25.14 25.73	25.15 27.06	101.00 30.33	99.75	77.60	64.03 67.29
1333	11	42.15	92.14 92.33	27.44	27.57 27.31	27.44 27.73	21.50 21.34	25.40	27.12	35.30 35.30	69.26 89.26	74.90 78.98	67.29 67.29
1971	2	44.92 65.12	43.10 43.10	20.36	24.03 26.03	28.36 29.36	25.83	28.45	21.52	99.20 99.20	47.99 67.99	11.60 61.80 41.60	65.98 65.98 65.98
1979	.	47.12	42.34	30.49 30.79 29.57	27.45 28.50 28.14	30.49 30.79 29.57	21.96 25.47 25.22	20.53 25.04 24.67	25.49 2/.47 ? 7. +1	39.20 33.43 43.43	67.39 90.66 90.66	\$0.00	62.24 62.24
1970 1970 1973	6	45.30 46.31 48.09	49.26 43.37 42.74	30. i6 31.12	20.14 24.23 27.79	30.36 31.12	27.24	23.12	27. 43 25. 56	33.40 100.00	90.66 90.86	40.00 79.00	62.20 53.73
1973) N	47.15	43.13	34.69 23.21	29.45 28.42	30.u9 29.21	29.72 29.28	53.61 55.66	25. 10 25. 11	100.00	90.46	79.00	53.73 54.73
1973	11	41.73	41. !n 48. 74	24.47 27.22	26.75 7 6.4 8	28.47 27.22	27.92 27.67	16.22	22.53 22.57	37.43 37.43 37.40	8 1.35 8 1.35	71.30 71.30 71.30	54.33 54.33 54.33
1971	12	41.19	40.35	26.42	26.14	24.82	27.46	15.46	22.43	77.40	41.37	. 2.30	.4.54

Table 113

TRIERWEILER A10 HANNEY 400at: Forecasting Performance

	PGC	P881	PBS2	Sdd	234	d d
COST DERIVED LOSS						
M.	.01	00.	00.	.01	. 31	.03
M	.02	10.	. 01	.03	. U.	. 15
χ H X	• 16	.07	•0•	÷1.		1.07
# J.3.	• 19	.08	.05	1.	۲4.	1.20
N # 1.00 (M.S.E.)	9.79	3.25	1.96	5.57	33. 34	87.61
INEQUALITY HEASURES						
C 1	. 7242	.7064	.6858	.7175	. 6135	. 7469
1 S	2,3326	2.0907	1.6226	1.5370	4964.4	4.1362
TURNING POINT ERFORS	32.	30.	.92	20.	•	•
AVERAGE ATSOLUTF EGKNP	2.50	1.46	1.03	1.62	5.79	7.63
AVERAGE RELATIVE ERROR	5.73	5.28	3.91	8.67	6. 4.7	10.46
THIRM ABSOLUTE MOMENT	47.15	8.70	£ . 4	23.54	303.56	1240.39
FOURTH MOMENT	258.03	26.07	11.43	120.23	2472.00	19548.92
CORELATION	.7185	.8417	.8577	.7682	6634.	.2561
SLOPE	1.0939	1.0546	. 8843	. 8253	2.1193	.3218
BIAS (AVERAGE ERROR)	1.9963	1.3195	.7302	5693	5267	6.4483

NO OF DISERVATIONS IN THE CALCULATION OF SAR SUBROUTINE # 72

Table A14

CHMM SIMULATIUM MODEL ACTUAL AMU RETIMATED : NOUENOUS VAMIABLES

(1) : SF C ı 10 4578 3954 925 931 1878 Je J 1702 ded 19:7 ACTUAL 4353 1651 2747 2856 10 14:3 12.9 4773 3000 ;; ** 1883 1884 4334 1344 :014 2746 3279 ;;; 214 27 34 1::3 11:: 3140 3164 ** 17 17 3 64 LAL4 4617 1:/3 1117 7019 ;;; 1344 125 ;; 13:3 9:7 473° 9:5 4070 7971 19 15;3 487,4L1 1830 71 1577 1250 1542 4757 3983-20.1 3 974 976 201 31 16:3 10:2 2578 "; 11 1: 3 ACTUAL :337 2956 2898 :743 1073 41 10 3405 97**6** 931 2170 474 1,4 12:1 74 83 ## 12:1 ACTUAL 13:3 3740 227.4 247.6 1277 1853 :::3 78A7 7918 *** 2120 #12 **3**4 14:7 11:1 4447 2845 2710 7° 1 11: 1 actual 33,7 1354 2755 \$353 5218 2710 1370 *** 1411 252 技 19:5 ;;; 47.2 38:5 ,;; 3/ 13:2 467L4L1 1343 34;3 977 1404 3333 1344 204 5.1 3 i::: ::1 47.07 241.0 ;; 34 14: Actual 5545 5243 1144 3471 3445 3243 1174 :33 1720 113 17:4 11:3 424 ?:;; ;; 33 14:7 467,463 11 1370 1463 3473 1772 H: 375 # 15:8 actual 5264 : 117 *33 318 33 14:3 3314 ;; 3713 1664 3351 3000 19:3 ## 13;2 actual" 3708 ;31 1112 211 31 4*4? 5144 3314 ... **;**; 3728 1323 :343 1383 1930 :21 1111 27 11 12:2 14:3 4785 11:1 ij 11 11: AFT. A. 11:1 4757 7013 90 31 12:3 ACTUAL 934 938 1074 433 1: 14:5 3261 1630 1419 3373 20.1 #1:3 . #7.a.4 13:2 333 31 11:3 1:1: 3:33 H H 33 33:3 15-1 1575 33:\$ 2413 331 1939 315 14;7 3047 3514 111 33 35;2 actual" 3710 3743 7079 11 7;2 9733 1173 1273 347 \$45 3452 1:: 38 19:3 ACTUAL" 1167 1871 1374 ::: 1200 ;;} ;; 11:3 ::} \$6.3 1323 4077 3868 ,;; BE A ACTUAL 1723 21; ,; 17:3 3813 133 : 327 3524 3173 737 1420 3842 3574 957 968 1074 313 22 17:5 11:0 7*57 7681 3716 ** IF; ACTLAL 5942 5002 10"3 7112 10:1 ACTUAL1 11:3 ::: 3;74 3315 ** 1211 1822 :::: 3822 ?:?? 957 1332 334 1 120 31 Big ACTUAL .471 1250 1:1 Ħ 11: ::1 3727 13/2 6473 1123 1144 711 950 4721 7714 :; * Mil ACTUAL 4041 1555 1303 J818 J9;1 7341 141 1347 *** 11 14:3 18:4 21 13:1 ACTUAL 14:4 3133 33: 3 H 2213 1265 3778 1847 4815 353 ;;; 1411 333 # 1::1 Mit actual }**\$**\$\$\$ 4373 7400 1858 *** Ħ 11;1 ::1 1744 3:11 13: :::: 1521 113 ::3 4764 333 H 38 HI: ACTUAL" 1773 17: #;4. :::; 1:31 7274 1498 1134 Ħ

Table Al5

CHOM SIULATION MODEL CATAMITES UPA JAUTSA

(2)

PRFEW	PRIFF	PRPU	ESO	toP	PHFOL	PHPL	PRF C	SF	PL	АЙЧИ ОДИ
39.68 41.61	22. ¥2 29. 97	47,38 47,88	242 257	412 184	24.42 24.73	14.78	19.47	2967 2983	4356 4554	64 3 Acèta
48:27	16:33	30:44	375	443 664	57.70	13;12	\$1:30	3707 2422	3211 3211	ACTUAL 4
42;24 30;75	29.65 26.66	46.56 41.34	232 245	494 432	24,36 22,95	14.06	72.03 20,70	2747 2178	4766 3922	AÇTYAL
30;66 43;53	38:47	48.48 46.21	244 172	474 424	24.47	21;15	20:69 23:61	4115 3712	3614	OS 2 AUTŲAL
17;23	31:12	51.06 24.16	244 194	111	22,14	23:03	20.96 34,40	2042 2548	4784 4565	AÇTÇAL
30;41 42;66	\$3:75 \$4:45	53.19 56.28	240 240	172 152	23;12 25;24	23.50	23:33	2478 2458	3121	ACTÝAL 4
17:17	3 3;33	34:31	217	£;	38; 77	26;71	27.96	2^81 2°21	4623	ACTOAL 1
46 : 13 44 : 28	33:33	54:63 53:16	100	402 414	20;41 26;41	23:38	20.92 20.91	1413	183 1	AÇTYAL 2
43:14	\$4:41 \$6:67	54:23	272 231	163 151	24; 99 25; 42	27:83	31:39	3757 3009	4866 4823	ACTŲAL 3
19:11	33:39	47;37 51;35	343	634	£1;£2	12;19	34;8J	3.15	782 3	ACTUAL 4
40.14 42.36	34:87 33:34	52.60 47.53	317 300	450 331	23.33 24.51	22.14 19.69	22.98	2452 2451	4994 4777	AÇTYAL
13:3	31:42	\$7:15 47:38	257 274	467 493	24;03	25.05 20,58	25.10 25.58	4783 4148	3001	ACTYAL 2
31:11	34:58 37:13	\$7:27 \$1:46	23A 243	139	20;00 20;45	24,34 21.03	28.46 27.22	3454 2947	\$479 \$ 765	er s
38:48 45:28	42:12	48.50 46.54	270 275	409 409	29.79 29.79	17:33	27.22 24.15 25.70	3433 2473	8775 8051-	AÇTYAL O7 4 AÇTYAL
45,73	34,50	46,74	275	440	25,79	17,60	25,70	2-73	8051-	ACTYAL
13:13	38:38	19:82	325	131	38:27	18;83	38:23	<u> </u>	3331	AÇTÇÂL 1
16:53	33:83	42:30	383	442 320	34;52	19:54	30;38	4767 4131	4533	AÇTÜAL 2
29:52	33:33	45.73 50.41	399	260 242	39:13	10;54 20;54	31:96	3"27	5°39	AÇTÇAL
#:!!	41:37 35:07	46.67 47.81	345 294	490	27,18 27,19	18.71 18.32	27.68 20.64	J423 2994	8784 8628	ALTYAL 4
41.56 48.13	33.30 37.41	45,52	287 275	332 470	24,14 27,63	18,45 20,29	20.61 27.46	2*40 2*14	512° 5230	ee 1
\$3;23	33:38	31:27	33A 256	420 312	34;33	20;40 22;60	37:44 31;50	j*\$\$	5288	ACTOAL 2
33:13	44:35	57;34 59;34	3::	107	33;33	24:33	34:33	37 4 4	323	ACTUAL 3
47:46	13:41	50,43 51,00	35? 341	44.5 21.0	20,77 20,10	25 29 26 82	24.97 34.60	3761	9746 4137	AGTŲAL 4
44: <u>?</u> \$	33;47	34.70 61.12	371	49.4 466	2/ (4/ 24 (4/	23,46 27,50	20.99 45,00	2705	\$3°1	ACTYAL 1
47:17 52:30	43,32	\$3;25	342 312	134	31,45	26,87 24,88	30,77 45,50	4n48 3713	3193	ACTUAL 2

Table A16

CROM SIAULATION HOBEL

A C.	ACTUAL ANU ES	STIMATED (3)	estimateu Endogenous (3)	VARIABLES	ω ·
PRFCA	H21	H22R	CHCS	H23	YFAR
21,22	26267	7061	4050	34332	.
21,45	26181	7100	4150	34238	ACTHAL
21,50	27045	7302	5301	34719	9
23,01	26874	7375	5535	34433	ACTHAL
25,47	27625	7819	6145	34550	6
26,40	27294	7500	5745	34045	ACTITAL
26,17	27912	800	5031	35426	•0
25,95	2755y	7920	5693	35405	ACTUAL
29,51	29764	8 4 7 8	4046	58479	69
26,43	27920	7820	5442	36077	ACTUAL
28,59	31624	8874	4775	40593	70
82,27	28102	9453	7626	13526	ACTUAL

Table Ai7 GROW SIMULATION MODEL: Forecasting Performance (1)

	æ ×	80 X	ă.	×	ESB	0 Ю	H 24	H224	123	S U H U
COST DERIVED LOSS										
N N N N N N N N N N N N N N N N N N N	20 20 20 20 20 20 20 20 20 20 20 20 20 2	00000000000000000000000000000000000000	74 4 5 4 0 4 6 6 6 0 6 6 6 7 0 6 6 6 7	0 0 4 4 6 0 0 4 4 6 0 0 0 0 0	28 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	0.15 1.36 14.36 14.37 20.50 20.50	20 20 20 20 20 20 20 20 20 20 20 20 20 2	0 20 20 20 20 20 20 20 20 20 20 20 20 20	825.79 23292.73 23292.73 30672.40 30672.40 29995.422002727.60	11.04 70.82 1236.24 1282.92
14EDUA_1TY 4:A3.11E'S U 1 U 2	6.4593 5.893	0,7227	0,7770	0.4747	1,1105	0,3113	0.7358	0,2804	4.02.0 4.02.0	1.5246
TURNING POTIT BRIDGE	'n	~	3 0	o	,	-1	0	-	N	-
AVERAGE AJJOLUTE EJ 132	62,39	7.27	7.40	7.05	37,21	44.97	1057,28	219,01	2014904	1005.85
AVE9AGE JELATIJE EAJJA	14.50	33,47	14.7	19,05	15,13	17,14	3.79	2,60	34.68	15.53
THIRD ABSOLUTE 4 JMEVT	591255,00	1053,59	1249,37	1213,35	191787,05	229204,96	63, 066466	Å6 1 666656	1213,33 191787,05 229204,96 994999;cp 959999;pp 99999;rb 90999;	66.656606
FOURTH MOVEUT	46.665406	15527,60	20288,72	10516.34	\$6.004404 \$0.040400 FE.61848	\$6.064464	65. 660666	A0166666	60*56666 A0*66666	66.066666
COARELATIOA	C. ^ 5	0.4280	0,6272	0.6/6?	6,5325	0,7947	6764.0	7048.0	-0.740	n,2122
SLOPE	6.6045	9.1963	0.9427	1.1161	0.5704	0.5733	0.3278	1,0494	\$415,50	0,7946
BIAS (AVEILAGE E9(DR)	1.3636	5,6764	4,1484	1,589 6	-16,9537	-17,6191	-17,6191-1057,2790		-8,984U-3040,68F&	A73,2844

NO OF SUARTFALY INSERVATIONS IN THE EVALUATION ROUTINE . 24

Table A18

GROM SIMULATION MODEL: Forecasting Performance (2)

	PHFCA	PRFC	9 4 19	B 25 25 25 25 25 25 25 25 25 25 25 25 25	PRFBU	PRPL	g. E.	PCFEC	2 12 12 12 12 12 12 12 12 12 12 12 12 12	8 d 0
COST DERIVED LOSS										
() () ()	24 / 0 / 6 / 0 / 0 / 0 / 0 / 0 / 0 / 0 / 0	00000000000000000000000000000000000000	0000M	0000 1000 1000 1100 1000 1000	00000	00004	00000	22779	0 H N O C	C C C C C
INEDUA_ITY HEASTES						•	•	-		•
	3. 800	0.6199	0.6079	1 603 1	0,6403	0,4398	0.5177	0,344	1275,0	1,3393
	3.9517	1.3487	1.7425	1,618?	1.6907	6156.0	1,1463	451610	90,240	0,770%
TURYING POINT ETIOKS	~	10	12	15	11	۰	1	•	æ	11
AVERAGE AUSOLUTE FREJR	10.01	4.16	2,03	3,31	3,25	1.82	3,48	62.0	£4.0	48.6
NVERAGE RELATIVE F423R	15.00	11.96	7,53	600	6.95	6.59	6 5.5	4,19	85 ° 2	4.04
THIRD ABSOLUTE MJME4T	25792,43	706.74	20,17	101,7.5	90.98	14,42	105:37	9.0	4 4 4	1.33
	1384230.41	12291,38	19,67	652,77	535,25	48,57	747.90	1,10	2,30	1.94
	J. 4034	8629.0	9875.0	0,7152	0,5965	0.7933	0.7258	1876 G	# · · · · · ·	9,140
	3,2093	1,3704	6,4292	0,6683	0.494	0,8592	0.7483	£094.0	6.5172	0,6299
BIAS (AVERAGE ERIDA)	8.7738	2,5234	0,1029	0,1999	9,8562	-0,0647	-0,0373	7942'0-	.0,0628	-0,1267
	٠									

NO OF BUARTERLY IRSTRANTIONS IN THE EVALUATION ROUTINE . 24

Table A19

CROM SIMULATION 100% : Forecasting Performance (3)

	٦ ا	E C	ANTE	CSFC	AKTAP	XHNFC	A A A A	\$	SED	•
COST DERIVED LOSS										
N N N N N N N N N N N N N N N N N N N	10.61 09.75 12.69.45 15.45 22.75.1.30	0.02 2.03 2.52 2.53 3.54 5.55 5.03	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	0000 0000 0000 0000 0000 0000	11. 111. 111. 100. 100. 100. 100. 100.	1.06 0,86 6.04 01.01 00.01 1004 100.00 1256299	9,88 101401 12763 256299	3 4 6 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4	20 - 0 - 0 - 0 - 0 - 0 - 0 - 0 - 0 - 0 -
INEDUA,ITY NGASTIES U 1	0.3245	0.3801	6,309,	16.3094	0,5110	0,4253	0,4265	0,4719	6.63.0	0,2749
U 2.	3.7345	0.8405	0.9311	565610	0.8050	0,9441	0.9525	1,1844	0.550	0,5937
TURNING POINT BRIONR	•	^	-1	>	v	•	ю	20	29	•0
AVERAGE ASUNLUTE ERROR	744.57	108,80	16.04	249,23	13,31	327.84	166,18	675,34	240,78	159,24
AVERASE HELATIVE E.43.3	19,54	3,41	1,51	4.1	1,46	12.02	11,08	15,69	4.97	5,24
THIND ABSOLUTE 4 METT	66.640604 49.04060	66*600606	10696,78	10,9499949,91	15262,31	65,066606 66,664666	65,066606	46 646656	14.AU4008840,2¥49484 ¥9,940938	190504.81
FOURTH MUNEUT	°6°666666	66.01.0600	349077,25		778774,62	65,000010 40,0099999 44,62 999999		46 666656	5 65 1 56 66 66 A 6 1 6 6 6 6 6 5 6	56.66666
CORRELAT:01	5.4.583	6,9333	0,7370	0.925.	0,534	0,7344	0.6852	0,3934	0,6274	0.4786
SLOPE	5.5444	0,8727	0,5>33	. 908.0	4968.0	0,5724	0.5051	0,7849	0.7074	9,6866
Blas (AVEHAGE ERIDA)	-549.6271	-31,1880	-9,6071	-92,789"	-10,6361	36,8099	17,3575	191,4469	-30,6754	-9.8224

NO OF DUARTEALY 1958RVATIONS IN THE EVALUATION ROUTINE . 24

Table A20

EXOGENOUS VARIABLES USED IN THE UNGER MUNEL

	LISAY	CHATGH	PPROTETN	ARANGECI	PFEEDIO:	NONIHPORT	NB I HPOKT
405.2729	29	24.2430	40.9480	75,5333	97.5224	-555.0000	555,0480
450.5735	32	23.9636	48.6987	82,3333	56.2715	-215,0000	327,0000
452,6083	5	24.5083	54.5474	77.6667	94.7881	-498,0600	445,0800
469,7334	₹.	23.3730	52.3588	61.6667	55,4996	-476.0600	532,0000
487,6238	89	22.3944	49.1509	61.000	91,116/	-167,0000	726,0801
496,6527	~	21.8986	44.0983	0000.00	64.0536	-136,0800	939,0000
508,3518	0	22,7434	45,3768	77,6667	80,7855	-372,0000	1274,0000

ANALYSIS 1 -- UNSER OLS

UNGER MOTEL ACTUAL AND ESTIMATE ENDUGENOUS VARIABLES

	YEAR	PBEEFR	Q#EEF C	PUMEATR	POEEFF	GREEFP	INEEFF	PUMEATF	IUEEFNF	BOMEATC	YOMEATP
ACT	43	71.97	14964,	49,84	16,45	18429,	9512,	14.74	73930;	21354.	21 vap.
EST	63	82,55	10325,	45,54	20:15	17776.	9319,	21.85	741947	20017,	21472.
ACT	64	74.07	19026,	53.00	19716	10699,	10110;	17.64	74740;	20769.	21864.
EST	64	99.31	17924.	75.56	25.87	17596.	9349,	25.0/	78999;	21517.	21/32.
≟CT	65	74,54	2015.	56,39	19.47	17694,	10031,	18.19	74891;	31J°3,	21491;
EST	45	114.51	1/399.	95.11	12:51	10954.	9763,	32.42	\$71567	21145.	21043 .
ACT	•6	72.11	28716.	50.98	17.10	20104.	18978;	15.17	79923:	22953,	23429;
EST	66	123.30	17661.	95.65	35.11	17149,	10452;	32.04	0.7515;	21948.	22424.
ACT	67	77.03	?1622.	49.59	19.31	29846.	12144,	14.75	76123;	23433,	23000.
EST	67	125.46	10874.	• • • 33	37;47	17298,	10053;	36.82	05446;	23317.	33 284.
ACT	68	75.41	22165.	48.39	20.50	21126.	12779,	16.02	78350:	23708.	23 044.
EST	•8	116.45	19327.	82.43	34.65	19388.	12010;	27.89	84585;	23972.	24180.
ACT	69	73.02	22925.	49,54	28.36	21451.	12349;	14.9*	01393;	24002.	84474;
EST	49	111.58	20438,	78.84	35·ú0	19164.	12461,	25.72	05975;	24433,	24005;

ANALYSIS 1 UNGER OLS		Forec	asting	Perfo	rmance					
	POLLFR	GHEELC	POMEATR	PBEEFF	OBEEFP	INELFF	POMEATF	IBEEFUF	ohuPV i C	OUMENTP
COST DENIVED LOSS										
N = 0.04 H = 0.12 M = 0.32 H = 0.34 M = 1.00 (M.S.E.)	.40 1.86 14.71 17.44 1671,146	10.19 72.45 1639.30 2153.44 376470,22	.3A 1.71 12.72 14.95 1131,97	3.01 4:17 180,74	1083;87	1.79 12.14 244.60 317.64 639684,28	115 ; 64 3; 82 4; 48 168, 58,	15,75 125,74 3791.03 5127,50 193215,65	;41 2; 42 47,61 84,64 285976,64	.40 2.07 44.77 87.48 2654 ⁹ 8.04
INFQUALITY MEASURES										
U 1	.9>74	.9832	.9472	.9107	,9854	:9212	19072	,7897	,4304	.1615
IJ 2	70.5871	3.6612	11.9667	14,95>6	4,4157	1;2535	7:4818	4,1400	,4845	.6125
TURNING POINT ERPORS	3,	₽.	2.	2.	3.	17	21	1.	2.	4.
AVERAGE ASSOLUTE EPROK	47.74	2530.02	32.24	12.12	2434:02	707.60	12:05	5632,10	430:10	136.10
AVENAGE PELATIVE LUNGH	:1.40	11.03	43.11	48.49	11741	4.25	/0:32	7,45	\$:40	1.04
THIND AUSGLUTE MONTHS	71744.55	984/51.82	42094.04	2544,72	• 104751:02	•749374.65	2302;37	193414.81	,114451;06	114171.04
FQUATH HOMENT	3467366.34	954468. 531	1425445.63	30460.49	• •>4808:50	•394292.57	84697.391	A55688.68	•217434:41	.217013.41
COMMELATION	.1767	.7174	.3635	.0139	.5207	19049	13741	.7199	,9202	.9107
SPULL	.013*	1.0140	.0903	.1797	.0177	78410	18737	,4423	,*204	.9469
ATAS (AVENAUL FARUE)	-17,7410	2339.0267	-32.2359	-12:1194	2470.0202	41377414	-1218453-	9638.1043	154,4945	151.4995

ANALYSIS 2 -- UNGER 25LS

UNGER MOREL ACTUAL AND ESTIMATE ENTOGEMOUS VARIABLES

	YEAR	PBEEFR	OWEEFC	POMEATR	PREEFF	UFEEFP	IBEFLL	PUMEATF	INEFFNF	BOMEATC	YOMEATP
ACT	•3	71.97	18984,	49.84	14.85	14429.	9512,	14.74	73938;	21354,	21700.
EST	43	82,36	10375.	66,22	19:62	1/920.	9502,	\$1.45	73996;	20017;	81372.
ACT	64	74.07	19826.	53.49	19.16	18499.	10116.	17.64	74748;	20749,	21004.
EST	64	94.61	10092.	77,05	24.98	1/765.	9459;	25.59	7894;	21517,	21/32.
ACT	65	74,54	28159,	56.39	19,47	19694.	10431;	10.19	74691;	21393,	31 0° 1.
EST	65	116,75	17742.	98.55	31.16	17257.	9817;	33.52	01529;	21145.	21044.
ACT	66	72.31	28716.	50.98	19.10	20184.	10978,	15.17	79923;	22953,	23420.
EST	66	121.13	16832.	98,94	33.76	1/500.	10572,	33.90	02014;	81948,	22424.
ACT	67	72,43	?1 622 .	49,59	19.31	28846;	12146.	14.76	74123;	23433,	23068.
EST	67	122.96	18452.	92.87	35.95	17676.	10949;	31.64	64726;	23317 ,	23484,
ACT	64	75.41	22065.	48.39	20.58	21126.	12779,	14.02	7#356;	23700,	83844;
EST	68	114.78	19645.	84,23	22.36	19706.	12130;	28.49	43474;	23972,	84100.
ACT	•9	73.;2	72925,	49.54	20.36	21651.	12345,	14.99	#1393 ;	24002,	84474.
EST	69	1110	20708.	80.41	31.00	17434.	12799,	26.25	#5457;	24433,	24005;

ANALYSIS 2 -- UNCER 25L5 Forecasting Performance

1	Po f Ef Ř	Odeefc	POMEATR	POEEFF	OBEEFF	IOEEFF	POMEATE	IDEEFOF	OQMEN I C	OUMEATP
COST DERIVED LOSS										
N = 0,04 N = 0,17 N = 0,32 N = 0,34 N = 1,00 (M,S,E,)	.37 1.71 13.54 16.81 14/9.805	7.95 56.59 1282.90 1686.84 830088.61	.42 1.91 14.28 16.68 1298,49	;12 ;49 3.92 3:48 180,375	8:24 50:53 1316:62 1729:30 643000;81	1.47 9.95 280.74 260.79 529100.57	117 171 9:22 4:85 179;85	13.17 104.70 3154.07 4264.72 483432,61	;41 2,72 4/;00 97;04 2 0 5700,04	.48 2.07 66.7/ P7.99 785998.64
INEQUALITY MEASURES										
U 1	. 9960	.9805	.9448	.9017	,9828	:9210	19124	. 4*02	,4304	.2613
U 2	19.6090	3,2517	12.7771	13,5440	4,0993	1;1399	710333	3,7697	,4045	.6125
TURNING POINT FARORS	3,	2.	2.	5.	2.	11	21	1.	2,	4.
AVERAGE AUSOLUTE FRANK	36.10	2467.36	34,36	10,92	2067;36	643,94	12;74	5004.23	430;10	438.10
AVFRAGE RELATIVE EPHON	49.22	9,78	67,22	56,21	10:13	5,45	44,45	6,64	1;48	1.94
THIRM AUSOLUTE HOMENT	64318.76.	*18834.31	91443,98	1874,>4.	710030;31	-231367,78	2732,34,	130067;21	114451;04	114951.64
FOURTH HOMINT	28847+9.37+	743>44,252	1132745,86	26367,740	783545:50	415617,78	43651.95,	784448.884	247834,41	217633.31
CORNELATION	-1967	.7667	.3757	.6364	.0300	:9003	15202	,7344	,9742	.9105
dfuhe	.8146	1.1076	.0454	.1974	1,0146	10350	18769	•4490	,9206	.9409
	•	206/.3607	+34.3951	-16.9235	2047.1407	514:2081	•12:73 46 •	5464.2242	154.4975	154.6925

NO OF DUSERVATIONS IN THE CALCULATION OF SAR SUBROUTINE . 7

ANALYSIS 5 -- UNCER DUK

UNGER MODEL ACTUAL AND ESTIMATED ENDOCHOUS VARIABLES

	YEAR	PBFEFR	OHEEFC	PUMEATR	PREEFF	USEEFP	INEEFF	POMEATF	INEELME	BONEATC	YOMEATP
ACT	63	71,97	16084.	49,84	16:45	16429.	95121	14.74	73930;	21354;	21900;
EST	63	82,71	18389,	66,70	19,45	1/834,	9421.	21.54	73925 ;	20017;	21472.
ACT	64	74,37	19824.	53,89	18.16	19699,	10116;	17.44	74740;	20789,	21004.
EST	•4	97,44	18142,	77.94	24.99	1/915.	9548,	25.93	78468;	21517.	81/32.
ACT	65	74,54	78139,	56,39	19.47	19694,	10031.	18.15	74691;	21393,	21091.
EST	65	116.75	1/798.	100.43	30:74	17345.	9963;	34.19	01335;	21145;	21043.
ACT.	, 60	72.21	28716.	56.96	19:10	28184.	10976,	15.17	25923 ;	22953.	2 3429;
EST	66	123.51	18153.	100.79	33:10	17481.	10665,	34.55	02594;	21948;	22424;
ACT	67	72.63	21422.	49.59	19.31	29446.	12146,	14.75	74123;	23433.	23000.
EST	67	122.78	18>61.	•4.33	35,50	1/765.	11025,	32.19	64>11;	23317,	23484.
ACT	68	75.41	22065.	48.39	20:48	21126.	12779,	16.87	Z#350:	23700.	23844.
EST	64	114.61	19737.	05.32	45.40	1479A;	12207;	20.90	83682;	23972.	24100.
ACT	69	73.62	72925.	49,54	20.36	21651.	12345,	14.97	0 13 9 3;	24082.	24474.
EST	69	189.49	20705.	81.39	31.49	17511.	12877;	26.63	85383;	24433,	24405;

Forecasting Performance

ANALYSIS 3 UNGER TINK	Parefi	QUCEFC	POMEATR	PREEFF	OUELFP	leftf	POMEATF	lyEEfyf	OÀMFY Í C	STABRUO
COST DERIVED LOSS										
N = 0,04 N = 0,12 H = 0,3? N = 0,34 H = 1,00 (M,S,E,)	.36 1.67 13.18 19.59 1437,134	7.35 52.39 1188.45 1962.82 678377.89	.44 2.03 15.21 17.90 1386.07	.11 .47 2.85 3.28 129,794	7.63 94;19 1219,79 1601:99 1679377:09	1.26 8.54 172.56 224.18 45768d,47	718 775 4;49 5;17 193;859	12; 37 94, 66 2976, 91 4014, 92 563082, 74	:41 2:42 67:00 89:04 285490.04	.48 2.07 66.77 57.98 285498.64
INEQUALITY MEASURES										
U 1	, 9753	.9796	.9508	. 4954	.9819	;4087	19156	.4837	,4304	.3813
n 5	19:3434	3,1332	13.2418	13.1163	3,9500	170601	6:1157	3,4544	,6845	.6125
TURNING POINT ERPOPS	3,	2.	2.	3.	3,	17	21	1.	2,	4.
AVENAGE ABSOLUTE EPHOR	35.56	1991.40	35.58	19.56	1991:40	>9>,06	13;20	4925,36	430;10	438-10
AVERAGE RELATIVE FURTH	48.47	7.42	69.61	54.52	9;75	5.20	e3;54	4.43	3 : 76	1.94
THIND AUSGLUTE HONEAT	41549.31+	887348.72	57341.34	1704.40	MA7348;92	381995,44	3030;520	127697,64.	114451;04	114451.04
FOUNTH MOMERT	2727834.16*	#33>95.122	408145.55	23427.42	433595.12	870003.29	\$0107,700	497612.00	217834;41	217433.31
CORNELATION	.1764	.8049	.3801	.0379	,4788	19109	18324	.7393	,9202	.9109
SLAPE	.8144	1.1299	.0831	.1910	1.0640	19267	18491	,4775	,9206	,9409
MIAS (AVENAGE ENPUM)	-15.5043	1791.3986	-35,5828	-28.5574	1801,1986	44471599	-13:2815-	4921.7492	154,6945	151.6985

NO OF OUSERVATIONS IN THE CALCULATION OF SAN SUBROUTINE . 7

ANALYSIS 4 -- UNGER ISLS

UNTER HOTEL ACTUAL AND ESTIMATEC ENDUGENOUS VARIABLES

	YEAR	POFEFR	OPEEFC	PUMEATR	PBEEFF	U ofilb	LREEFF	POMEATF	INEFFRE	MOMENTO	HOMEATP
ACT	63	71.97	10964,	49,84	16;45	18429,	9512,	14.74	73934;	21354,	21400.
EST	63	83,70	16614,	64,67	18;04	18259,	9438,	21.02	98543;	20773,	\$1150;
ACT	64	74.37	17824.	53.00	18.16	14499.	18116.	17.64	74746;	20709,	21004;
EST	64	96.31	18504.	75.75	52:55	18759.	9515.	25.54	1831687	21473,	21040;
ACT	65	74.54	28139.	56.39	19.47	19494.	10831.	18.19	74891:	21393,	21091:
EST	65	112.13	14663.	93.61	27.70	18234.	9927,	32.44	185244;	21254.	31/52.
ACT	. 66	72.31	20716.	50.98	19.10	20184.	10976,	15.1/	59923 ;	27953,	23429.
EST	60	114.36	19223.	92.82	29.27	10491.	18677;	32.42	106265;	22044.	\$2>28.
ACT	67	72.63	?1622.	49.59	19.31	79946.	12146;	14.75	76128;	23433;	23008.
EST	67	115.40	19622.	97.29	31.68	13846.	11010;	30.24	107136;	23343,	23>10.
ACT	66	75.41	22005.	48.39	20.58	21126.	12779;	16.82	7.4350;	23700.	23044;
EST	69	183.74	21039.	75.48	27;94	23100.	12228;	25.69	184924;	24100,	24236.
ACT	69	73.22	72925.	49,54	20,36	21651.	12345,	14.97	0 13 ° 3;	24002,	24474;
EST	69	90.41	22284.	69.14	25.59	21010.	12918;	22.36	188183;	24659,	25eJ1.

ANALYSIS 4 -- UNGER SSLS

Forecasting Performance

	PBFEFK	OMEEFC	POMEATR	PBEEFF	OWEEFP	INEFLE	POMEATF	INEEFOF	GAMPY (C	QUMEATP
COST BERIVED LOSS										
N = 0,04 N = 0,12 N = 0,37 N = 0,34 N = 1,00 (M,5,E,)	.26 1.26 9.43 11.14 1808,331	. 2.21 15.77 359.41 472.59 433911.22	.31 1.41 10.43 12.26 915.58	;04 ;24 1;44 1.06 61,771	2:28 16;25 367;79 4PJ:29 443911;22	1.25 8.50 171.79 223.21 45477/.27	:14 ;37 3:37 3:88 140,68,	284.87 2818,49 72136.88 97844,35	737 2.04 61:24 80.06 759410,01	
INEQUALITY MEASURES										
U 1	.9447	.9135	.9387	. 9549	,9465	:4020	19040	.9416	,3824	.3577
U 2	16,1716	1,7361	10.7623	2.0405	2,1887	1:0590	617279	19.0620	,45>7	.5833
TURNING POINT EMPORS	3.	1.	1.	2.	1.	11	11	1.	2,	4.
AVERAGE ABSOLUTE EPROR	79.30	1032.44	28,71	7, Q A	1032:44	591.38	11715	28724,26	402;39	407.45
AVERAGE RELATIVE EPHOR	40.00	4.91	54.61	36;>4	5:07	5,14	70741	37,66	1;44	1.61
THIRD AUSOLUTE MONE IT	34790.01+	0 15147.06	31532,44	5*5,73.	414147;86	#29681.05	1950:33,	050464;47		910A>73. 9 7
FO ШИТИ ИОМЕЗТ	1414545.84.	136684,371	143382,50	4130.74	13/684;39	>02249.64	20707.060	416145.00	, 0 14449:08	,914149.00
CORRELATION	.1711	.9813	,5229	./1>1	.0440	14074	13307	.4*10	, 73.15	.9755
SLOPE	.0127	.9725	,1252	.2049	. 9540	;0216	11019	.5725	,08>3	.9041
RIAS (AVENAGE ENPOP)	•20.3061	1032.4169	-28.7061	77.0434	1032,4366	42717875	+2111495	8728.2559	88,5074	A4.5086

NO DE ONSERVATIONS IN THE CALCULATION OF SAN SURPOUTINE . 7

AMALYSIS 5 -- UNGER ISSLS

UNGLE MODEL ACTUAL AND ESTIMATED ENDURENBUS VARIABLES

	YEAR	PBEEFR	QHEEFC	PUMEATR	PBEEFF	UFLEFP	INEFLL	POMEATF	INEEFAF	BONEATC	YOMEATP
ACT	43	71,97	18984.	49,84	14.65	18429.	9512,	14.74	73936;	21354,	21789,
EST	63	76,17	19247,	61.63	17.12	10492.	9466.	19,67	73144;	20750,	21405;
ACT	64	74.67	17826.	53.09	18.16	18499.	10110,	17.64	74740;	20799,	21864.
EST	64	9:.43	19137.	71.61	21.92	18810.	9565,	23.90	77487;	21458,	21045.
ACT	65	74,54	28139.	54.39	19,47	19694.	10031,	18.15	74891;	21393,	Z1091.
EST	65	94,75	19883.	82.81	23.77	19438.	19818;	28.84	7A734;	21JR4.	21482.
ACT	. 66	72.31	78716.	50.98	19.10	20184.	18978.	15.17	75923;	22953,	23429.
EST	66	181.59	28396.	82,94	25.53	14864.	10769;	28.31	79734;	22115.	\$5>91.
ACT	67	72.63	21622.	49,59	19:31	28946.	12144;	14.75	76123;	23433,	23 000.
EST	67	104.72	20641.	79.03	28.09	19915.	11000;	26.84	016847	23164.	23>31:
ACT	66	75.41	22065.	48,39	20.50	71126.	12779,	16.02	783507	23760;	23044.
EST	69	9.5.00	21923.	67.07	25.00	79784.	12327,	22.11	00716 ;	24274.	744187
ACT	69	73,62	22925.	49.54	20.36	21651.	12345,	14.99	01393 ;	24602.	84974;
EST	69	84.60	23371.	58,59	21:58	22097.	13010;	18.03	0 1636;	24924;	25296.

AMALYSIS 5 -- UNIGER 135L5 Forecasting Performance

	PB+ E F B	DWEEFC	POMEATR	POEE'F	OJEEFP	IUEEFF	POREATE	INEEFNF	GĠW₽ Y į C	OUMENTP
COST DERIVED LOSS										
N = 0.04 h = 0.12 N = 0.32 h = 0.34 h = 1.00 (M.S.E.)	.13 .60 4.60 9.43 464,87	.26 2.01 40.22 60.63 178841.97	.10 .02 5,90 7,01 499,98	: #2 . 10 . 60 . 69 24, > 6	:29 2:88 47:43 62:38 198841:97	1.08 7.35 148.89 193,49 399227,89	:88 :38 1:91 3:20 75;36	4.39 34.93 1844.27 1413.91 971699,87	;30 2;/8 64.00 05;11 226200,19	.38 2.74 63.87 64.19 276488.19
INFQUALITY HEASURES								•		
U 1	,9139	.3356	.9168	,7945	,4169	: 6253	10623	.5004	,46==	.3289
U 2	11.8236	.6334	7.9530	5./001	,7985	; 7901	518788	2,1505	,4706	.6019
TURNING POINT ERPONS	3,	1.	2.	2.		1:	21	1.	5,	٠.
AVENAGE AUSOLUTE EPHON	19.52	352.6 3	20.64	4,17	3 52; 8 3	543.62	7:94	2745,16	434;>4	430.54
AVENAGE RELATIVE ENHIN	26.62	1.67	40.42	21.59	1;73	4,72	50710	3,64	1:46	1.93
THIND AUSOLUTE HONFUT	17219.56	433450.15	13126.67	165.09	333920;72	252110.24	403;02+	624842,32	av; 7470£ 4-	,610769,98
FOURTH HOMENT	JJ73/0.1t	117215.56	364047.48	1822,23	112215.54	229>32.61	9148;97+	45794.00	·247476;¥3	237776.03
COPRELATION	.1121	,95>2	.9541	.6169	,9304	17101	13432	.7017	,42>1	.9262
SLOPE	.4157	.9464	.1534	.2263	.9363	16127	11276	.4827	,6414	.0542
RIAS (AVERAUF EMPOR)	-19,5152	110.3**6	-24.6397	74.1491	114,3994	353;5698	•7:9486=1	1530.1953	-4,0202	-1.0202

NO OF OUSERVATIONS IN THE CALCULATION OF MAN SUBROUTINE . 7

ANALYSIS . -- UNGER LISE

UNGLE MUTEL ACTUAL AND ESTIMATED ENDUGENOUS VARIABLES

	YEAR	POEEFR	QHEEFC	PUMEATR	PREEFF	UNEEFP	IBFELL	PUMEATF	INEELME	BONEATO	yone atp
ACT	43	71.97	18964,	49,84	14;45	14429,	9512;	14.74	73930;	21354,	\$7466.
EqŢ	•3	76,15	18421.	59,31	18,40	1/766,	34325,	275,22	73782;	20017,	21472.
ACT	64	74.07	19024.	53.49	14.16	1:400.	10114;	17.44	74748;	28789,	21064.
EST	64 .	79,15	10407.	67.74	22.39	10000.	49278,	434.29	77629;	21517.	21/32.
ACT	65	74,54	76139.	54.39	19;47	17694.	10731;	18.19	74891;	213*3,	31 09 1.
EST	65	84.38	10354.	01-10	27:11	1/909.	68015;	627.61	791417	21149.	21043.
ACT	. 66	72,31	26716.	50.98	19.10	20104.	19978,	15.17	76923;	22953;	23420.
EST	60	45.23	18748.	81.69	29.14	. 10256.	72648.	666.43	681441	21946;	22424 .
ACT	67	72.83	21622.	49,59	19.31	28846.	12146,	14.75	76123;	23433,	\$3000;
EST	67	93.96	19275.	79.39	31.78	1:499.	71117;	449.47	01776;	23417;	23484.
ACT	68	75,41	22065.	48,39	20:54	21126.	12779;	16.02	74350;	23700,	73844 ,
EST	68	91.76	28317.	72,94	29.74	1/3/8.	4687/;	611-14	014077	23972.	24100.
ACT	69	73.02	22925.	49.54	28.36	21451.	12345,	14.99	01393;	24002,	24974;
£ST	69	68.64	21287.	69,45	28:05	23013.	62895,	230.53	03296;	2 4433;	24005.

Forecasting Performance AMALYSIS 6 -- UNGER LISE 10EEFWF COST DERIVED LOSS INEQUALITY HEASUPES U 1 ,8643 .9714 .9145 .4663 .5853 .3843 .6125 U 2 TURNING POINT EMPORS AVERAGE ADSOLUTE EPHOR AVERAGE RELATIVE FRANK 15.33 THIRD AUSQLUTE MONEHT 494.37-899462:21-551013.88;29A388:88;219679,77;114451;66;114951.66 FOUNTH HOMENT 7214.12-545514:87-087616.88-497543:39-815493.88-217834:31-717833.81 CORRELATION .1664 .3247 :7343 .9185 .6247 .1078 .2341 . 1.2754 1.2116 14412 .4574 . 9449 MIAS CAVERAGE ERRORS

NO OF CHISENVATIONS IN THE CALCULATION OF SAN SUBROUTINE . 7

Table B1
Structural Equations for the Hayenga - Hacklander Model

```
Live Cattle Demand:
                                                              P.V.E. - .877
Pc* = 22.14 - 0.402 Qc* - 0.161 Qh* + 11.266 I + 0.030 Pcow - 1.66 Feb
                                           (11.34) (4.61)
                 (7.02) (2.87)
          - 1.33 Mag - 1.09 Apr - 0.98 May - 1.42 Jun - 2.63 Jul - 1.72 Aug
         + 0.01 Sep - 0.44 Oct - 2.13 Nov - 2.97 Dec .
Live Hog Demand:
                                                                 P.V.E. = .969
Ph* = 34.52 - 0.769 Qh* + 0.192 Qc* + 0.038 \Delta Stor* - 0.023 Stor t-1 + 4.28 I (2.81)
                                        (2.67)
                  (6.91) (2.71)
          - 1.11 Feb + 0.13 Mar - 0.64 Apr + 0.64 May + 0.81 Jun
          - 0.89 Jul - 1.69 Aug - 1.88 Sep - 1.76 Oct - 0.20 Nov
          + 0.97 Dec .
Change in Pork Storage:
                                                                 P.V.E. = .882
\Delta Stor^{*} = -23.71 + 3.611 Qh^{*} + - 2.299 Ph^{*} - 0.292 Stor_{t-1} + 20.62 Feb
(4.25) (1.89) (3.75)
         + 19.12 Mar + 43.08 Apr + 16.81 May - 12.23 Jun - 21.08 Jul
          -43.00 Aug - 41.12 Sep - 24.14 Oct - 12.14 Nov - 11.38 Dec .
                                                                 P.V.E. - .810
Cattle Supply:
Qc* = 13.98 + 2.458 \Delta Pc* + 0.013 S<sub>9</sub> + 0.016 S<sub>7</sub> - 0.014 H<sub>7</sub> + 0.010 H<sub>5</sub> (2.56) (2.89) (2.79)<sup>7</sup> (1.35)<sup>7</sup> (1.38)
          - 0.0002 D_2 S_7 + 0.015 D_2 H_7 - 0.004 D_2 H_5 - 1.56 (Jan + Feb + Mar) (0.04) (1.69)
          - 0.71 \text{ (Apr + May + Jun)} + 1.56 \text{ (Oct + Nov + Dec)}.
                                                                 P.V.E. = .840
Hog Supply:
Qh* = 12.89 - 2.34 \triangle Ph* + 0.013 P<sub>180</sub> - 0.003 P<sub>120</sub> + 0.0001 P<sub>60</sub> - 0.005 D<sub>1</sub>P<sub>180</sub> (4.77) (4.55) (2.37)
         - 1.12 (Mar + Apr + May) - 2.20 (Sep + Oct + Nov) - 2.94 (Dec + Jan + Feb) .
* indicates the endogenous variables.
P.V.E. is the proportion of the variation of the normalized endogenous variables
```

explained by the predatermined variables in the system. The numbers in parencheses are analogous to the t statistic.

Table B2

Structural Econometric Model From Myers, et al.

	æ	ф. Ч		چ چ	Pch	ф СРФ	2	2	9 di)	3		عه ج	Ave Vap Const Nh v	Nh 's	Pcr	క	Š	ខ	3	-	Qch	٠	₽∧g	ਚ	R 2
•	I	***	****	Endo	######################################	Vari	ables	***	*****	****		***	*****	*****	sstatsstatstatstatst Predetermined Variables ************************************	redet	ermin	.e A pa	riable	*		****	!		
Hog Supply	-	26.	26.6 0 0	0	0	0	9	0	0	0		0	1143	. 019	1143 .019 3.50 271		-36.5 0	•	0	0	0	1.65 Yes	• •	1.65	.87
Pork Margin	0 +	- -	.0019 1548 U	၁ စ	0	9	0	0	0	0	r	9	-2.60 0	0	•	5	0	0	0139	0	0	.048 No	o _N	0.55	68.
Retail Pork Supply	25	1	251 to 1.64 0	0	0	0	0	၁	-	0	•	.153	323	0 4.14	0	108.1 0	0 1	0	0	0	•	.899 Yes	¥.	1.85	.95
ketail Pork Demand	0		. 0610		0233	э	0	0202	0 2	၁	•	0	4.39	0	•	0	0	0	600. 0	760	0	0	¥.	1.88	.81
Retail Beef Demand	0	0	00130 0		0037	-	•	.0595	0 9	0		0	3.03 0	0	0	0	0	0	6970. 0	697	0	0	Yes	1.93	.93
Retail Broiler Demand	0	0	0	0 3.54	-	2.00	0	0	0	0		0	69.61 0	0	0	0	0	0	0 .303	·- £01	-23.5	0	Yes	0.65	.92
Cattle Supply	0	0	0	0	0	0	32.1	0	0		•	0	1146	1146 0 47.2	237.6	0	.078	.078 451.7 0	0	0	0	3.11	Yes	1.11	.93
Beef Margin	0	0	0	0	0	0	-	-,484	0	0026	•	0	-8.73 0	0	0	•	0	•	085	0		002 No	o _N	0.70	.94
Pork Supply- Demand Identity	٥ ,	0	0	-	0	၁	0	0	0 - 1/Popn	0	•	0	0	0	0	0	0	0	0	0	0	0	S S		
Beef Supply- Demand Identity	o ,	•	0	0	0	-	5	0	٥.	0556/Popn		0	0	0	•	0	0	0	o .	0	0	0	No No		

* Coefficient less than two times standard error. + Coefficient less than three times standard error. This presentation assumes the model is of the form A y * B x + u. All equations estimated by to stage least squares methods.

Table B2, Continued

Equation	January	January February	March	April	Мау	June	July	August	Septembe	r October	September October November	December
Hog Suppl y 1346	1346	1062	1155	1065	1096	1133	1077	1086	1027	1140	1211	1316
Cattle Supply	1164	870	1038	976	1099	1138	1186	1286	1294	1416	1190	1089
Pork Supply	331	262	330	282	298	298	299	336	352	390	347	347
Pork Demand	4.77	3.99	7.60	4.13	4.20	4.17	4.03	4.28	4.44	4.63	7.68	4.81
Beef Demand	3.40	2.42	2.88	2.71	3.07	3.03	3.06	3.27	3.15	3.49	2.95	2.92
Broil er Demand	68.00	62.30	71,33	70.96	73.58	73.25	74.42	75.06	71.13	66.62	63.91	64.75

Coefficients of the Dummy Variables in the Myers, et al. econometric model.

Table B3 Estimated Coefficients for Myers' Stage I Equations

7	g T	ā.	0,0	a T	n 90	ů	3	SÃO	j o	
-427.09300	67.15600	162.53600	.11600	55.60106	-11.63750	100:34600	239,29300	101200	-2762.51u08	CONSI
-204.6200	.62700	.7520	85730	1,32100	-,75400	-1,71900	-3,13400	•147,45400	-240,12000	FEB
-251.0000	1,35600	2,76510	•• •0000	3.32230	-,22800	-1.61800	-4,24200	+61,26000	-89,19000	Z A Z
-325.32000	.53999	1.57780	-,72900	4.41668	36867.	. 93560	-3,18600	•117,97600	189,19428	APR
-:97,03090	000000000000000000000000000000000000000	4710	-,47900	4,93204	000gř.	.46700	-, 23660	16,43960	-139,46000	HAY
-264.53330	.19830	035+9*	37300	6,58700	00606	2.18600	3,77980	-57,98700	-194,28000	NOT
-321,57000	19800	01536.	-,41400	6,59966	00984	3,41200	5,23600	-60,55600	-232,73000	106
-315.20030	00262.	1.541.0	-,25360	9.27968	58900	3.68360	5,51600	-26,20603	-171,59000	904
-425,73000	3,46400	6,28910	48960	9,64760	1954	4,11000	4,39600	-56,84100	-189,14000	SEP
-340-41030	5.13860	7.98170	27260	8.34800	01450	3.06400	4,74380	-11,93000	-40,34000	100
-229,44030	4,21000	3,54579	-,37100	5.47400	67930	3,21300	5,35000	-39,53800	-219,02000	AON
-73.55030	2,14630	2.23359	082:0	2.09500	61230	1,33000	2,40400	-, 29400	-194,68000	Dec
.33030	00640	00960	.00006	00004	-,00003	.0000		.00960	81000	I
15.69000	68233	27950	.04830	-1.36809	92389	40300	-, 22180	9,91500	46100	œ
226.56000	.05600	.4570	, 33200	47409	.10800	1,75800	3,67000	31,01300	62,65900	PACAR
416.75000	•17.31400	-27,89170	1,38800	2.95900	13061	-1,44600	2,1900	227,36200	93,52000	3
1,10690	00903	.05880	00003	18800	03030	.23900	,54100	1, 23700	-4,50100	-
35630	.50200	.03250	00005	00400,	130C4.	100150	100300	000000	.05400	N.
32,21200	02500	-9,10730	19830	03669.	3,04160	-16,72000	-42,54100	16,91600	1074,73000	Ŋ.
11.67600	45200	76610	.02400	44360	. 96500	67700	-1,31200	9,03500	14.91400	>
.27403		61750	,21060	.39700	-,21500	00400	00600.	00852	0Dc25	980
-3.31500	.20830	15670	.00020	.21100	.08899	-1.17400	-3,46186	-3,45800	144,54008	-
20300	. 52360	.02350	-,23900	-2,63500	.04130	00900*	, 62500	-,27800	-,23900	H)O

Table B4

Structural Equations from Trierweiler - Hassler Model.

Retail Beef Demand:

Retail Pork Demand:

Retail to Wholesale Structure for Beef:

Pbc* = 9.96677 + 0.74830 Pbr* - 12.95590 Wr - 0.60680
$$\triangle$$
 Qbd R² = .804 (0.03842) (0.82630) (0.15065)

Wholesale to Slaughter Structure for Beef:

$$Pbs_1^* = -4.35784 + 0.68975 Pbc^* + 0.19009 T$$
 (0.01482)
 (0.01702)
 $R^2 = .951$
 $R^2 = .951$

Retail to Slaughter Structure for Pork:

$$Pps* = -12.77266 + 0.55540 Ppr* - 1.34337 Wr R = .855$$
(0.02180) (0.72409)

The numbers in parentheses are the standard errors of the coefficients.

Individual Equations of the Unger Model

- (1) Demand for Beef at Retail.
- (2) Marketing in the Cattle Beef Sector.
- (3) Supply of Beef Cattl on Farms.
- (4) Inventory Demand for Beef Cattle Retained for Feeding.
- (5) Inventory Demand for Beef Cattle Not Retained for Farm Feeding.
- (6) Demand for Other Meat at Retail.
- (7) Marketing in the Other Livestock Meat Sector.
- (8) Supply of Other Livestock at the Farm.
- (9) Cattle Beaf Sector Identity.
- (10) Other Livestock Meat Sector Identity.

The system is presented in the form A Y = B Z + U, Where the A matrix is above the row of vertical equality signs.

Table B5
Estimated Coefficients of the Unger Model (Ordinary Least Squares)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(Endogenous)										
Pbeefr	1.0000	1400 (.0402)				-,5657 (.0749)				
Qbeefc	.00744 (.0008)								1.0000	
Pomestr	3572 (.1179)					1.0000	3502 (.0282)			
Pbeeff		1.0000	105.78 (26.86)	-47.697 (19.933)	-387.01 (73.18)					
Qbeefp		.00261 (.00045)	1.0000						-1.0000	
Ibeeff2				1.0000						
Pomeatf				76.080 (32.223)			1.0000			
Ibeefnf2					1.0000					
Qomeatc						.00806 (.00134)				1.0000
Qomeatp							.00116 (.00037)	1.0000		-1.0000
(Predetermined)	11	11	18	10	11	11	11	el	11	11
Constant	37.01 (8.16)		8024.64 (2057.42)		-11093.4 (4168.1)	84.99 (9.18)	23.44 ((5.62) (2	3378.9 2267.6)		
Dispy	.3910 (.0336)	.1126 (.0201)				.250 8 (.0511)	.0308 (.0157)			
Cmktgm		4330 (.1191)					5370 (.1442)			
Ibeeffl			.4534 (.2030	.9204 (.0659)						
Ibeefnfl			.1452 (.0273)		1.0234 (.0209)					
Pprotein			-56.27 (18.11)							
Arangeci					53.58 (53.05)					
Pomeatfl								187.97 (67.60)		
Pfeedidl								-79.15 (20.99)		
Qomeatp1								.8308 (.539)		
Mbimport									1.0000	
Nomimport										1.0000
2 R	.9364	.9744	.9842	.9710	.9938	.8283	.9581	.9732		
D. W.	1.24	1.63	1.41	2.81	1.07	1.25	1.57	2.86		

Table B6
Estimated Coefficients of the Ungar Hodel (Two Stage Least Squares)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	(-)	(-)	(-)	('')	\- /	(0)	(,,	(0)	(7)	(10)
(Endogenous)										
Pbeefr	1.0000	1091 (.0456)				6419 (.0872)				
Qbeefc	.00744 (.0009)								1.0000	
Pomestr	3357 (.1348)					1.0000	3444 (.0290)			
Pbeeff		1.0000	92.08 (28.18)	-42.635 (21.161)	-377.83 (76.74)					
Qbeefp		.00303 (.00052)	1.0000						-1.0000	
Ibeeff2				1.0000						
Pomeatf				60.437 (37.917)			1.0000			
Ibeefnf2					1.0000					
Qomeatc						.00894 (.00172)				1.0000
Qomeatp							.00120 (.00044)	1.0000		
(Predetermined)	11	н	H	п	11	11	11	11	11	11
Constant	38.40 (9.29)	20.88 (3.07)	7665.29 (2084.33)	957.13 (1036.12)	-11138.2 (4171.6)	86.50 (11.38)	24.24 (6.23)	8378.9 (2267.6)		
Dispy	.3910 (.0376	.1307 (.023)				.2787 (.0650)	.0324 (.0188)			
Crulet gm		3803 (.1266)					5449 (.1556)			
Ibeeff1			.4521 (.2046)	. 944 7 (.0727)						
Ibeefufl			.1458 (.0275)		1.0239 (.0209)					
Pprotein			-55.19 (18.26)							
Arangeci					56.11 (53.45)					
Pomeatfl								187.97 (67.60)		
Pfeedidl								-79.15 (20.99)		
Qomestp1								.8308 (. 0 539)		
Mbimport									1.0000	
Nomimport										1.0000
R ²	.9363	.9729	.9839	.9706	.9937	.8155	.9580	.9732		
D.W.	1.26	1.86	1.40	2.85	1.07	1.40	1.54	2.86		

Table B7
Estimated Coefficients of the Unger Model (Unbiased K - Class)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(Endogenous)										
Pbeefr	1.0000	0966 (.0468)				6726 (.0903)				
Qbeefc	.00746 (.0009)								1.0000	
Pometr	3274 (.1349)					i.0000	* -,3426 (.0290)			
Pbeeff		1.0000	87.73 (28.35)	-40.310 (21.356)	-374.35 (76.77)					
Qbeefp		.00320 (.00054)	1.0000						-1.0000	
Ibeeff2				1.0000						
Pomeatf				52.330 (38.266)			1.0000			
Ibeefaf2					1.0000					
Qomestc						.00939 (.00178)				1.0000
Qomea tp							.00121 (.00044)	1.0000		-1.0000
(Predetermined)	11	μ	ti .	11	11	#	4	н	11	u
Constant	38.93 (9.30)	21.30 (3.15)	7551.18 (2096.57)	770.31 (1045.66)	-11155.1 (4173.3)	87.77 (11.79)	24.49 (6.24)	8378.9 (2267.6)		
Di epy	.3914 (.0377)	.1381 (.0239)				.2935. (.0673)	.0329 (.0188)			
Cnaktgm		3586 (.1298)					5474 (.1557)			
Ibeeffl			.4517 (.2058)	.9571 (.0734)						
Ibeefnfl			.1460 (.0277)		1.0241 (.0209)					
Pprotein			-54.85 (18.37)							
Arangeci					57.07 (53.47)					
Pomeat fl								187.97 (67.60)		
Pfeedidl								-79.15 (20.99)		
Qomeatpl								.8308 (.0539)		
Mbimport									1.0000	
Homisport										1.0000
R ²	.9361	.9715	.9837	.9700	.9938	.8019	.9579	.9732		
D.7.	1.27	1.93	1.07	2.85	1.07	1.44	1.53	2.86		

Table B8
Escimeted Coefficients of the Unger Hodel (Three Stage Least Squares)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(Endogenous)										
Pbeefr	1.0000	1100 (.0336)				6536 (.0686)				
Qbeefc	.00676 (.00077)								1.0000	
Pomeatr	4713 (.1089)					1.0000	3563 (.0246)			
Pbeeff		1.0000	79.286 (24.074)	-36.475 (17.390)	-358.63 (67.72)					
Qbeefp		.00304 (.00038)	1.0000						-1.0000	
Ibeeff2				1.0000						
Pomeatf				49.330 (30.498)			1.0000			
Ibeefnf2					1.0000					
Qomeatc						.00843 (.00135)				1.0000
Qomestp							.00130 (.00036)	1.0000		-1.0000
(Predetermined)	H	n	u	u	44	16	11	16	n	11
Constant	28. 92 (7.55)	21.38 (2.24)	5093.26 (1432.29)	731.67 (850.52)	12564.8 (3419.8)	82.86 (9.02)	24.00 (4.98)	9933.1 (1810.1)		
Dispy	.3654 (.0322)	.1311 (.0171)				.2577 (.0511)	.0364 (.0153)			
Conktgm		4043 (.0846)					5380 (.1185)			
Ibeeffl			.6826 (.1497)	.9669 (.0599)						
Ibeefnfl			.1364 (.0203)		1.0263 (.0186)					
Pprotein			-32.27 (12.14)							
Arangeci					77.66 (43.20)					
Pomeatf1								224.89 (51.85)		
Pfeedidl								-96.28 (15.94)		
Qomeatp1								.8083 (.0451)		
Mbimport									1.0000	
Nomimport										1.0000
R ²	.9322	.9727	.9809	.9696	.993 7	.8142	.9572	.9721		
D.W.	1.18	1.84	1.05	2.88	1.05	1.34	1.60	2.89		

Table B9
Estimated Coefficients of the Unger Hodel (Iterated Three Stage Least Squares)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(Endogenous)										
Pbeefr	1.0000	1751 (.0258)				6558 (.0647)				
Qbeefc	.00667 (.0007)								1.0000	
Pomeatr	4571 (.0941)					1.0000	3474 (.0242)			
Pheeff		1.0000	65.67 (34.47)	-38.811 (17.101)	-362.11 (63.68)					
Qbeefp		.00222 (.00028)	1.0000						-1.0000	
Ibeeff2				1.0000						
Pomeatf				49.584 (30.343)			1.0000			
Ibeefnf2					1.0000					
Qomeatc						.00803 (.00112)				1.0000
Qomes tp							.00128 (.00033)	1.0000		-1.0000
(Predetermined)	11	·t	f+	r	•	•	•	•	/1	H
Constant	29.63 (6.51)	19.15 (1.80)	-974.665 (1160.22)	677.61 (849.65)	-10803.69 (2567.72)		23.09 (4.53)	13237.9 (1815.7)		
Di spy	.3621 (.0300	.0949 (.0127)				.2421 (.0423)	.0349 (.0136)			
Cmktgm		5087 (.0542)					4737 (.1057)			
Ibeeffl			.7927 (.1123)	.9695 (.0597)						
Ibeefnfl			.1701 (.0167)		1.0260 (.0182)					
Pprotein			22.74 (7.463)							
Arangeci					54.56 (29.77)					
Pomeatf1								246.35 (50.68)		
Pfeedidl								-120.57 (15.36)		
Qomeatp1								.7487 (.0481)		
Nbimport									1.0000	
Nowimport										1.0000
R ²	.9322	.9729	.9636	.9697	.9937	.8129	.9562	.9651		
D.W.	1.20	1.32	0.809	2.88	1.07	1.29	1.66	2.73		

Table B10
Estimated Coefficients of the Unger Model (Limited Information Single Equation)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(Endogenous)										
Pheefr	1.0000	0181				7798				
Qbeefc	.01726 (.01059)	(.0718)				(.1256)			1.0000	
Pomeatr	1.2755 (1.7228)					1.0000	-2.6212 (87.0304)			
Pbeeff		1.0000	54.24 (33.39)	-7.681 (37.516)	-237.19 (94.90)					
Qbeefp		.00428 (.00087)	1.0000						-1.0000	
Ibeeff2				1.0000						
Pomeatf				-92.960 (92.073)			1.0000			
Ibeefnf2					1.0000					
Qomente						.01167 (.00247)				1.0000
Qomea tp							.17710 (6.71704)	1.0000		-1.0000
(Predetermined)		•	¥	Ħ		u	N	11	11	**
Constant	148.04 (117.36)	23.85 (4.30)	6672.29 (2316.29)	-2740.17 (2354.29)		96.58 (15.19)	1901.59 (71690.65	8378.9)(2267.6)		
D1 spy	.7790 (.4211)	.1852 (.0835)				.3725 (.0920)	7.4940 (284.93)			
Cniktgm		2190 (.1824)					-42.6475 (1607.81)			
Ibeeffl			.4485 (.2251)	1.1779 (.1571)						
Ibeefnfl			.1474 (.0303)		1.0323 (.0235)					
Pprotein			-52.20 (20.12)							
Arangeci					94.91 (60.71)					
Pomestfl								187.97 (67. 6 0)		
Pfeedidl								-79.15 (20.99)		
.Qomeatpl								.8308 (.0539)		
Mbimport									1.0000	
Homimport										1.0000
g ²										
	.0852	.9513	.9805	.9237	.9922	.6962	-773.6	.9732		
D.W.	1.08	1.95	1.27	2.01	1.00	1.49	2.01	2.86		

Table C1
Reduced Form Equations Corresponding to Myers' Structural Model

_	* * *	* * * * * *		* * * *	Undogenous	Variables	* * * *			
Exogeno Variabl		Ph	Pp	Qpd	Pch	Qbd	Pc	Pb	Qp ∎	Qc
1011001		The fol	lowing coe	[[iclents	are multipl	ied by one	١.			
Usp	277	0.01(1	1.0219	0016	U.0049	0.0004	0.0000	0.0000	0.0000	0.0000
ИР	0.0060	0.0005	0.0009	0001	0.0002	0.0000	0.0000	0.0000	0.0000	0.000
R Prern	-10.4625 85.1199	0.52>2 6.9861	0.9221 13.0434	0.0120 4181	0.2937 2.9439	1678 7297	1.4711	3.0395	0.0000	0.0000
Ch	-313.5891	10.4174	17,9225	-1.0304	3.1265	0.2446	7.4037 6.0000	15.2969 0.0000	0.0000	0.0000
Nc	0.0000	0,0000	0.0000	0.0001	0.0002	0003	0.0024	0.0050	0.0000	0.0000
Cc	0.0000	0 .0€33	0.0000	0.6171	1.2713	-1.7257	14.0757	29.0819	0.0000	0.0000
W	1.1615	0437	0.1780	0064	0.0387	0080	0.0000	0.1758	0.0000	0.0000
I Qch	0.0000	0.0000	0.0000	0.0134 5023	0.1602 -21.5589	0.0475	0.0000	0.0000	0.0000	0.0000
Ť.	-2.396	0.1521	0.1816	0060	0.0406	0798 0097	0.0000 0.0970	0.0000	0.0000	0.0000 0.0000
Jan	-480.7007	68.6859	128.4152	0.3780	67.0902	2145	35.2707	92.9767	0.0000	0.0000
Peb	-377.0397	54.1094	102,1752	0.6696	60.7940	4327	27.1096	74.0487	0.0000	U.000 0
Mer	-537.9164	63.6554	119.0372	0.6762	69.6635	3642	32.3445	84.8647	0.0000	0.0000
Apr May	-432.0079 -466.9966	56.2891 58.7703	105.9622 110.3687	0.9009 0.9233	68.7096 71.3386	4702 5144	30.4126 34.2.53	80.8731 88.7919	0.0000	0.0000
Jun	-455.3714	59.7244	112.1501	0.8421	71.6275	6795	35.4606	91.3028	0.0000	0.0000
Jul	-475.7618	58.3855	109.6360	0.9451	72.7975	8618	36.9563	94.3931	0.0000	0.0000
Aug	-576.3692	62.5068	116.8079	0.9091	73.7181	9382	40,0723	100.8312	0.0006	9.0000
Sep	-639.6354	62.6672	116.8813	0.9849	69.8493	-1.1022	40.3216	101.3462	0.0000	0.0000
Oc t Nov	-710.3619 -567.8457	69.5756 66.8865	129.2425 124.8295	0.5124 0.4663	66.9674 63.9055	-1.0795 8225	44,1231 37,0809	109.2007 94.6506	0.0000	0.0000
Dec	-534.8552	69.5941	129.8848	0.1799	64.9062	3962	33.9337	88.1481	0.0000	0.0000
									0.0000	0.0000
		The fol	llowing coe	fficients	are multip	lied by Pop	rulation/g	(Populatio	on).	
Q*p	-2.4659	0.0927	0.1607	0097	0.0269	0.0038	0113	0265	8821	0.3802
Nh	0810	0.0030	0.0053	0003	0.0009	0.0001	000%	0009	0290	0.0125
R	18.6413	7009	-1.2144	0.3175	0.2998	7110	5.2280	11.7028		-167.7757
Prera Ch	-649.7954 -1586.0803	24.4330 59.6383	42.3328 103.3298	-1.3302	9.609	-2.4426	22.7380 -7.6206	50.8992 -17.0588	-232.4398 -567.3604	-729.7068 244.5605
No	0.1656	0062	0108	-6.2451 0.0011	17,2786 0010	0014	0.0093	0.0208	0.0592	2980
Ce	959.1362	-36.0645	-62.4857	6.1113	-5.6376	-7.9952	53.7726	120.3706		-1725.6713
W	-9.9>87	0.3743	0.6488	ú251	v.1375	02-2	0.2490	J.5575	-3.5623	-7.9923
I	20.8793	7851	-1.3602	0.0072	3821	0.1780	-1.4799	-3.3128	7.4688	47.4928
Qch T	-780.7711 -9.3280	29.3575 0.3507	50,8656 0.6077	-2.7780 0103	9.1160 0.1354	0.3639 0317	2.4856 0.3009	5.5640 0.6735	-279.2914 -3.3067	-79.7630 -9.6557
Jen	587.5373	-22.0920	-38.2768	2.4968	-6.0228	-1.4100	6.6833	14.9607		-214.48.
Feb	1040.7661	-39.1339	-67.8137	4.5003	-10.5030	-2.7161	13.4825	30.1807		-432.6804
lier	1050.9661	-39.5174	-68682	4.4373	-10.8327	-2.4417	11.3489	40.40.4		-364,2099
Apr	1400.2547	6511ء۔۔۔	-91.2237	5.8898	-14.4788	-3.1910	14.0521	32.7935		-470.2139
Kay Jun	1435.1041 1308.8680	-53.9614 -49.2148	-93.4940 -85.2700	6.0844 5.8607	-14.7401 -12.8019	-3.4048 -3.9762	16.0281 21.1749	35.8791 47.4002		-514.3744 -679.5438
Jul	1469.0279	-55.2370	-95.7041	6.724	-14.0663	-4.9728	26.0531	60.1109		-861.7696
Aug	1413.0975	-53.1340	-92603	6.6301	-13.1977	-5 1394	29.2346	65.4419		-938.1955
Sep	1530.8551	-57.5618	-99.7320	7.3096	-14.0756	-5.9229	34.3452	76.8820		1102.2054
Oct	796.4410	-29.9470	-51.8865	4.5519	-5.7591	-5.1761	33.6380	75.2991		1079.5112
Nov Dec	724.8449 279.6737	-27.2549 -10.5160	-47.2221 -18.2202	3.9059 1.6237	-5.7212 -1.9702	-4.0486 -1.8883	25.6287 12.3444	57.3702 27.6331		-822.4770 -396.1576
					are multip					
≎sp	0.0168	0006	0011	0.0001	0002	0000	0000	0000	0.0060	0.0000
Nh	0.0006	0000	0000	0.0000	0000	0000	0000	000	(,0002	0.0000
g Prorn	0.5554 7.8565	209 2954	0362 5118	0005 0.0164	0115 1155	0.0066 0.0286	0533 ^6 :	1193 6003	0 .1987 2.8 104	1.7099 8.6055
ግኑ	10.7953	4059	7033	0.0400	1227	0096	0000	0000	3.8616	0.0000
•• .	0.0000	0000	0000	C000	0000	0.0000	0001	0002	0.0000	0.0028
Cc	0.0000	0000	0000	0242	0499	0.0677	5098	-1.1412	0.0000	16.3605
ň	0.1072	0040	0070	0.0003	0015	0.0003	0031	0069	0.0383	0.0988
I Qch	3519	0.0132	0.0229	0005	0.0056	0019	0.0164	0.0367	1259	5259
γε π Τ	6.1423 0.1094	2310 1	4002):1	0.0197	0761 0016	0.0031 0.0034	0647 0036	1448 0080	2.1972 0.0391	2.0755 0.1150
Jan	-3.4864	0.1311	0.7271	01	0.0357	0.0084	0400	0896	-1,2471	1.2846
Peb	-5.9575	0.2240	0.3881	- 51	0.0591	0.0170	0880	1969	-2.1311	2.8226
Mar	-6.3167	0.2375	0.4115	0265	0.0654	0.0143	-,0653	1462	-2.2596	2.0963
Apr Hay	-8.4783	0.3188	0.5523	0354	0.0883	0.0185	0822	1839	-3.0328	2.6370
Jun	-8.5551 -6.9319	0.3217 0.2606	0.5.73 0.4516	0362 0330	0.0880 0.0637	0.0202 0.0267	0947 1544	2120 3455	-3.0602 -2.4796	3.0392 4.9537
Jul	-7.3702	0.2771	0.4318	0371	0.0637	0.0338	-,2053	4595	-2.6364	6.58/2
Aug	-6.6376	0.2496	0.4324	0357	0.0527	0.0368	2327	5210	-2.3744	7.4691
Sep	-6.8357	0.2570	0.4453	0386	0.0503	0.0433	2799	6265	-2.4452	8.9815
Oct Nov	-1.4624	0.0550	0.0953	0201	0136	0.0424	3091	6920	-,5231	9.9204
Dec	-1.9929	0.0749	0.1298	0183	0.0002	0.0323	2296	5141	7129	7.3696 3.6607
3	4428	0.0167	0.0289	0071	0061	0.0.55	1141	2553	1584	3.000/

The $g(\pi)$ polynomial is $g(\pi)$ - 556.0 - 9.9043691807 π + 0.039240698583829 π^2 .

