AN EX POST EVALUATION OF THE PREDICTIVE ABILITY OF TWO EARLY ECONOMETRIC MODELS: BURLEY TOBACCO AND MICHIGAN DRY BEANS

Thesis for the Degree of M. S.
MICHIGAN STATE UNIVERSITY
RICHARD R. SHERLOCK
1971

X 830

ABSTRACT

AN EX POST EVALUATION OF THE PREDICTIVE ABILITY
OF TWO EARLY ECONOMETRIC MODELS:
BURLEY TOBACCO AND MICHIGAN DRY BEANS

By

Richard R. Sherlock

A considerable volume of work has been done in the agricultural economics profession on the problems of specification and on procedures for estimating econometric models. Much of this has been concerned with the use of aggregate time-series data for analysing demand and supply relationships in agriculture. However, little effort has been made to evaluate these models explicitly, especially those based upon structural concepts, for their ability to forecast. This is in spite of a growing emphasis on this aspect in the econometrics profession which has developed and demonstrated methodologies and tools for this purpose.

The objective of this thesis was to demonstrate the use of some of the methodological concepts developed largely by the latter profession to make a preliminary evaluation of the econometric models based upon aggregate time-series data developed for two studies which were investigating production and price relationships for the burley tobacco and Michigan dry bean industries. More specifically, the objective was to determine whether the structural relationships specified in the

models were valid and whether or not they might provide a useful basis for making predictions. This included a cursory examination to ascertain to what extent the predictions from the models might be useful in terms of their timeliness and accuracy.

The method of analysis used to evaluate the structural validity of a model and its usefulness in the light of this for predictive purposes is the same as for showing that it represents a verifiable forecast procedure. Each model was used to make predictions of the dependent variable on an ex post basis. These predicted values were then subtracted from the actual values to give the forecast errors for the model. If the model was correctly specified and estimated the forecast errors should be of the same general magnitude and distribution as the residuals for the model. Where this is not the case, either the model was incorrectly specified and/or estimated, or a change in the behavior of the industry had occurred, or possibly both. To determine which was the case, on a preliminary qualitative basis, historical records were examined for evidence which would substantiate the nature of the departures signified by the forecast errors.

Analysis for the years 1950-1970 for the burley tobacco models and from 1953-1970 for the Michigan dry bean models, showed that where a model could be verified as structurally correct, it was useful in explaining the forces underlying the forecast values and for indicating changes in the structural relationships of the industry where they occurred, as well as their probable nature. This was regardless of whether the model came from the burley tobacco study where the explicit objective was to construct models for predictive purposes or from the dry bean study where it was not.

As a corollary it was concluded that a preliminary analysis such as undertaken in this study does provide a useful indication of a model's predictive performance, and possibly a useful foundation for more rigorous tests which were suggested.

To obtain an indication of their timeliness and accuracy, the forecasts were examined to see to what extent they met the requirements for verifiable forecasts. This analysis suggested that if attention had been given, in both studies, to when the models would have been used for making predictions, more timely and more accurate definitions for some of the explanatory variables would have been indicated.

Finally the results of this study suggest that econometric models can be a most useful tool for forecasting aggregate responses. How valuable they will be depends upon how well they represent the phenomenon to be predicted and the timeliness and accuracy of their predictions. Thus the construction and use of such models should be undertaken with these criteria in mind and therefore should ideally be based upon a liason between the user, the researcher and experts in the various sections of the industry represented by the model.

AN EX POST EVALUATION OF THE PREDICTIVE ABILITY OF TWO EARLY ECONOMETRIC MODELS: BURLEY TOBACCO AND MICHIGAN DRY BEANS

By

Richard R. Sherlock

A THESIS

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

MASTER OF SCIENCE

Department of Agricultural Economics

1971

ACKNOWLEDGEMENTS

I wish to thank the many persons who have helped make my graduate studies at Michigan State University such a worthwhile experience.

In particular, I wish to express my appreciation to Dr. Glenn L. Johnson for serving as my academic adviser and for his astute guidance in the development of this study.

Thanks are also due to Dr. Dale E. Hathaway, Dr. Lester V. Manderscheid and Dr. James B. Ramsey who served on my thesis committee, for their constructive criticisms.

My thanks again to Dr. Hathaway for the financial assistance that the Department of Agricultural Economics provided for this study and my graduate program. I also wish to acknowledge the New Zealand Department of Agriculture who granted me study leave for the duration of my stay in the United States.

Finally, no small part of this study belongs to L. O., R. and T., and the rest of the clan.

TABLE OF CONTENTS

Chapter | Page

LIST OF TABLES

LIST OF ILLUSTRATIONS

Figure		Page

CHAPTER I

INTRODUCTION

Over the years there has been an increasing demand for a better understanding of the interrelationships within the agricultural economy and between this and other sectors of the economy.[1] Much of this demand comes from the desire of policy-makers to be able to predict better the consequences of present policies or the impending need for new policies and to obtain more accurate indications of what these policies should be in order to best provide for the interests of the group in society a policy-maker represents.

To this end, whether it be at national, regional, state, sector, or industry level, the mere ability to be able to predict a future response, while vastly superior to no prediction, is not likely to be nearly as useful as to also know the structural relationships underlying the aggregate response.

The attempts of economists, agricultural economists and econometricians to meet this demand began to gain impetus in the 1930's concurrently with the increase in availability of reliable aggregate data and the development of various techniques for statistical analysis. Employing a framework of interrelationships suggested by economic

---

[1]For a more extensive discussion see Karl A. Fox, "Suggestions for Further Adaptation of Econometric Models to the Appraisal of Economic Policies", Econometric Analysis for Public Policy, (Ames, Iowa: Iowa State University Press, 1958), pp. 266-271.

theory and making use of the various statistical techniques available, estimates were made of the coefficients of the hypothesized explanatory variables subject to the limiting assumptions required by both the economic theory and statistical technique, thus "fitting" the equations to the data available.

In terms of both subject and time, this work can be divided into two classes. The first emphasizes the estimation of models per se. It is this aspect which has been given by far the greatest attention by the agricultural economics profession. Much of the effort has been concerned with using aggregate time-series data to analyze production and prices i.e. supply and demand responses in agriculture.[2] Indeed it has led to a marked increase in the degree of sophistication with which such models are specified and also in the techniques used for their estimation. This should lead to an improvement in the performance of these models when the emphasis of the second category of work is considered.

This second class of work shows greater concern for the evaluation of models and their use for forecasting or prediction (these two words will be used as synonymous). In the econometrics profession, it seems that this shift in emphasis from estimation per se to model

---

[2] Earl O. Heady, _et al._, editors, "II, Demand and Supply", _Agricultural Adjustment Problems in a Growing Economy_. (Ames, Iowa: Iowa State University Press, 1958); Glenn L. Johnson, "The State of Agricultural Supply Analysis", _Journal of Farm Economics_, Vol. 42, No. 2, (Proceedings Papers, Winter Meetings, American Farm Economics Association, May 1960), has a good review of supply work up until that time; Heady _et al._, editors, _Agricultural Supply Functions: Estimating Techniques and Interpretations_, (Ames, Iowa: Iowa State University Press, 1961). More recently Karl A. Fox and D. Gale Johnson, editors, "Introduction", Readings in The Economics of Agriculture, (Illinois: Richard D. Irwin, Inc., for AEA, 1969) give an overview; and see also numerous issues of _The American Journal of Agricultural Economics_.

evaluation and forecasting took place in the late fifties and early sixties.[3] Unfortunately this development appears to be only slowly taking place in the field of agricultural economics; that is, if the literature of this profession is taken as an indication.[4] It is a conclusion which, if correct, must be viewed with concern, since it is stressed that these two aspects, estimation and evaluation, should mutually reinforce each other. This thesis will focus on the evaluation of the use of models, derived from structural relationships, for making predictions.

The Need for Forecasts.--It seems useful to distinguish between three types of forecasts. Firstly there are trivial forecasts. In this case there is no real alternative to the event predicted. An example would be to predict that the G.N.P. for the United States will be positive next year.

A second type might be called judgemental forecasts. A great many predictions are of this type. They are distinguished by the fact that although completely valid and often complicated procedures are used to arrive at the final forecast, this process cannot be exactly replicated.

It is the third type that will be considered in this thesis. These are "scientific" forecasts and in particular the forecasts

---

[3]This is noted by Richard C. Haidacher, "Some Suggestions for Developing New Models from Existing Models", American Journal of Agricultural Economics, Vol. 52, No. 5, (December, 1970), p. 816, based on a survey of the changes in focus in the econometric profession over time by Saul H. Hymans, "Estimation Techniques and Econometric Forecasting", Papers of the Michigan Academy of Science, Arts and Letters, Vol. 52, pp. 249-258, 1967.

[4]This is elaborated somewhat below p. 11.

obtained by using econometric models. Following Theil's definition, scientific forecasts are those which can be verified and which are based upon procedures that can be verified.[5]

Forecasts, of whichever type, are an attempt to reduce uncertainty. Where there is no control over the phenomenon being forecast, it is an endeavour to improve expectations or anticipations. Where the phenomenon is at least partially controlled by the forecaster, it is an attempt to improve a plan. In either case, basically, predictions are made because there are some important aspects of the future which are not known. The question is, how can the best procedure for making the optimal predictions in a given situation be determined?

Evaluation of Forecasts

Intuitively, the simple answer to the question posed above would be that those predictions which optimize present decisions should be regarded as the best predictions. The limiting and, from a practical standpoint, trivial case is where a procedure allows the future to be forecast with absolute certainty.

In a real situation, where it is degrees of uncertainty, rather than perfect knowledge versus uncertainty, that are involved, the best forecasts may be considered to be those which are most conducive to the attainment of one of three broad objectives with respect to the value of the outcomes. One objective might mean that the best forecasts are those which lead to minimization of the losses associated with wrong decisions. Alternatively, the best forecasts might be considered

---

[5]The condition for verification are given below p. 15 and see also Henri Theil, Applied Economic Forecasting, (Chicago: Rand McNally and Co., 1966), pp. 10-14.

to be those which lead to the maximization of the gains from right decisions, or the objective might dictate that those forecasts which give rise to the maximization of the average net returns from all the decisions based upon them are best. This implies that what is needed to evaluate the worth of a set of predictions, is knowledge of the distribution of the errors for that set of forecasts and of some sort of preference function for the decision- or policy-maker. In other words, an error-cost function is required. For a decision-maker this might be based on a profit-function. In the case of the policy-maker, it could be based on an appropriate welfare function.[6] Obviously, however, the lack of availability of data on welfare or profit functions will, in many practical situations, require more simplified techniques to be used to evaluate the quality of a set of forecasts.

Practical Measures of Forecast Quality.--One simple method used for determining the accuracy of forecasts is to count the percentage of turning points in a time-series that are correctly predicted. Another similar procedure is to determine the degree to which the rate of change of the model's forecasts corresponds to the direction and size of observed changes. These two measures can be combined into a useful diagram which also indicates over and underestimation of levels,

---

[6] For a more comprehensive discussion of the use of error-cost functions and their consequences for evaluating forecasts see Ibid. pp. 15-29; also John R. Meyer and Robert R. Glauber, "The Purposes and Evaluation of Economic Forecasts", Investment Decisions, Economic Forecasting and Public Policy, (Boston: Harvard University, Division of Research, Graduate School of Business Administration, 1964), pp. 194-205; and Theil, Economic Forecasts and Policy, (Second edition, Amsterdam: North Holland Publishing Company, 1961) p. 452 ff.

as well as changes.[7] This method has been used in empirical work by Theil, Zarnowitz and Stekler.[8] However, it is a method which has the disadvantage that it does not allow the performance of a model that makes quantitative predictions to be judged on a cardinal basis. Turning-point errors that involve only a small discrepancy receive the same weight as large errors in predicting changes of direction.

Other measures that have been used are: the coefficient of determination, R^2, the standard error of estimate, average absolute error, mean error as a percentage of actual change, and range, amongst others. Finally Theil's inequality coefficient or U-statistic, which can be decomposed into two sets of inequality proportions, is probably the most widely used measure of the quality of a set of forecasts. Meyer and Glauber[9] make a very interesting comparison of the usefulness of these various measures. They compare the measures for different models, both for the period in which they were fitted and for a period extrapolated beyond this. In addition they compare the same models over these two periods when they are estimated by different techniques and finally using constrained versus unconstrained coefficients. From this analysis they concluded that the U-statistic was the most useful and consistent measure of the forecasting accuracy of a model.

---

[7] See Theil, Applied Economic Forecasting, op. cit., pp. 19-26.

[8] See Ibid.; Theil, Economic Forecasting and Policy, op. cit.; Victor Zarnowitz, "An Appraisal of Short-term Economic Forecasts", National Bureau of Economic Research: Occasional Paper 104, (New York: National Bureau of Economic Research, Columbia University Press, 1967); and Herman O. Stekler, Economic Forecasting, (New York: Praeger Publishers, 1970).

[9] Op. cit.

In particular, the U-statistic not only incorporates the absolute discrepancies between forecast and observed changes but its inequality proportions allow the relative importance of five different sources of the total forecast inaccuracy to be calculated.[10] Examples of empirical analysis using the U-statistic may be found in most of the references that have been cited.

State of the Art: In the Econometric Profession

As has been pointed out above,[11] model evaluation and forecasting began to be emphasized in the econometrics profession in the late fifties and early sixties. In fact this appears to largely coincide with Theil's work, especially the development of his U-statistic.[12] Since this work, empirical investigations, particularly in the field of aggregate national forecasts, have added considerable practical knowledge and valuable experience to the evaluation of models for forecasting.[13]

---

[10] The derivation of the U-statistic and the inequality proportions and their meaning are explained in Theil, Applied Economic Forecasting, op. cit., pp. 26-36. It should be noted however, that to date no rigorous test has been devised to judge whether the difference between two U-statistics is statistically significant.

[11] See pp. 2 and 3.

[12] Theil, Economic Forecasts and Policy, op. cit., 1961, and Ibid., first edition, 1958.

[13] See Theil's work. Ibid., 1958, 1961 and 1966 amongst other publications by this author. He investigates a range of models from macro-economic models for the Netherlands and Scandinavia to those for entrepreneurial predictions for prices and inventory. Meyer and Glauber, op. cit., analyse models for forecasting investment at various levels. Zarnowitz, op. cit. analyses the accuracy of short-term aggregate economic activity in the United States. Stekler, op. cit., and "Forecasting with Econometric Models: An Evaluation", Econometrica, Vol. 36, 1968, pp. 437-463 investigate the accuracy of forecasts made by a group of macro-economic models of the United States Economy. This list of references is by no means complete.

A number of useful improvements and clarification of methodology have occurred. Amongst these has been the exposition of the appropriate use of ex ante versus ex post evaluations by Zarnowitz[14] and Stekler.[15] An ex ante approach allowed the former author to show the extent to which errors in predicting the future were affected by errors in estimating the present in one study. Stekler on the other hand used an ex post evaluation to assess the structural validity over time of the models he was investigating.

Stekler, in both references, also suggests alternative naive models that might be used with which to compare the forecasting ability of a model being tested using the U-statistic. Which naive model is used depends on the situation and nature of the model being tested.

There have been other developments which should eventually lead to more useful forecast models and thus better forecasts. Zellner[16] shows how forecasts can be constrained within bounds which are considered reasonable by the forecaster, using some simple decision criteria. The key is that they must be specified beforehand so that their effect on the distribution of the forecasts is predetermined. In other work Zellner and Tiao, and Zellner and Chetty lay the

---

[14] Op. cit.

[15] Op. cit., 1968 and 1970.

[16] A. Zellner, "Decision Rules for Economic Forecasting", Econometrica, Vol. 31, 1963, pp. 111-130.

foundations for the use of information in a Bayesian manner in forecasting models.[17]

This survey then gives some idea of the scope and focus of work that has been done in the econometrics profession to date in evaluating models and increasing the usefulness of forecast models and their predictions.

State of the Art: In the
Agricultural Economics Profession

As was indicated above,[18] considerable work has been done in the agricultural economics profession on increasing the sophistication with which aggregate time-series models are specified and of the procedures with which they are estimated. This should improve the quality of forecasts made in this field. However, if the literature of this profession is any indication, there appears to be a relative lack of emphasis on model evaluation and forecasting.

Probably the most comprehensive attempt at model evaluation and, to a much lesser extent, measuring the accuracy of forecasts in the field of agricultural economics was that made by Fox.[19] He considered the demand supply relationships for a large number of agricultural commodities and various aggregates of them. The econometric models

---

[17]A. Zellner and G. C. Tiaco, Bayesian Analysis of the Regression Model with Autocorrelated Errors", Journal of the American Statistical Association, Vol. 58, 1964, pp. 1125-1132; and A. Zellner and V. K. Chetty, "Prediction and Decision Problems in Regression Models from the Bayesian Point of View", Journal of the American Statistical Association, Vol. 60, 1965, pp. 608-616.

[18]See p. 2.

[19]Op. cit., Econometric Analysis for Public Policy, especially Chapter 7 and the appendix.

used to represent these relationships were estimated largely from time-series data for the years 1922-1941. He then attempted to use these models[20] to evaluate the extent to which demand structure changed from this period to the post World War II period.

Three approaches were considered. The first was to examine one by one the various factors that might have been expected to change demand structures and to make rough estimates of their potential effects. The second was to observe the accuracy of price forecasts from the demand equations estimated for the 1922-1941 data during the postwar period. The third was to estimate new demand functions exclusively from postwar observations and compare them with the estimates based on the prewar data.

The last method was not attempted because of insufficient "normal" postwar observations. In the second method, accuracy was measured by the number of forecasts falling outside two standard deviations of estimate. If a ratio of less than 1 in 20 did so, it would be considered that the demand structure before World War II reasonably represented that after the War.[21]

The conclusion, from the analysis using methods one and two, suggested that while some changes were indicated, no major structural shifts had occurred in demand structure. In the process it indicated

---

[20]The assumption was that the prewar demand structure had been measured with reasonable accuracy by them.

[21]Note that this implies a more stringent test than if the tolerance interval had been based on the standard error of <u>forecast</u> which is wider than the standard error of estimate.

that structural models can provide a useful basis for evaluating the consequences of future structural changes.

In more recent times, from a survey of the last 28 issues of the American Journal of Agricultural Economics, Haidacher[22] concluded, that out of 39 articles focused on the estimation of economic relations of which 9 did some sort of projection or forecasting, not more than 5 indicated this as an explicit objective. In fact in the issues of the last year only two articles appear which estimated models which were evaluated for their forecasting ability. In both cases the models were non-structural and were tested against non-structural models.[23] As Fuller appropriately concludes in discussing this approach,

> . . . the forecast error [from models using only the past observations of the series itself] is the error a person completely uninformed in economics can be expected to obtain. An economic model adds information only if it can reduce the forecast error below this point.[24]

To be more specific and as Marschak shows,[25] where a specified change in structure is expected or intended, predictions of variables of interest to the policy- or decision-maker require some knowledge of past structure. This was also the basis Fox used in his work that

---

[22]*Op. cit.*

[23]Andrew Schmitz and Donald G. Watts, "Forecasting Wheat Yields An Application of Parometric Time Series Modeling", *AJAE*, Vol. 52, No. 2, (May, 1970), pp. 247-254; and Jurg Bieri and Andrew Schmitz, "Time Series Modeling of Economic Phenomena", *AJAE*, Vol. 52, No. 5, (December, 1970), pp. 805-815.

[24]Wayne A. Fuller, "Discussion", *AJAE*, Vol. 52, No. 5, (December, 1970), p. 813.

[25]Jacob Marschak, "Economic Measurements for Policy and Prediction", W. C. Hood and T. C. Koopmans, editors, *Studies in Econometric Method*, Chapter 7, (New York: John Wiley and Sons Inc., 1953), pp. 1-26.

was described above. Accordingly this thesis will be concerned with models which emphasize the structural relationships of the phenomena they would be used to predict.

The Objective of This Study

From the previous discussion a number of suggestions have emerged. In summary, these are that while there has been considerable work done in agriculture on estimating structural models based on time-series data, there is a need to evaluate these models to determine whether they could provide a useful basis for making "scientific" predictions.[26]

Work by the econometric profession has provided the basis for testing the accuracy of such models, the U-statistic in particular being an appropriate measure. The ultimate test of any such model would be an ex ante[27] evaluation, comparing the performance of the model with a naive model or possibly one of the more sophisticated naive models[28] if appropriate, or even an alternative structural model. First, however, it is expedient to test the structural validity of the model. For this purpose an ex post evaluation, preferably

---

[26]As defined above, pp. 3 and 4.

[27]That is, as the model would have been used in practice with the data that would have been available to the forecaster at that time. Testing the data as well as the model in this fashion is called for since the performance of any model can only be as good as the data used in it.

[28]See Fuller, _op_. _cit_.

using data from a period after that for which the model was fitted, should be used.[29] This will be the immediate focus of this thesis. It is hoped that it will demonstrate an initial step towards the ultimate objective of more intensive evaluation of structural models especially for the purpose of making verifiable predictions.

Specifically, the objective will be a qualitative ex post assessment of the structural validity of models which have the specifications outlined above. This will be accomplished by comparing the forecast values with the actual values of the dependent variables for data beyond that with which the models were fitted. Where discrepancies between these values are indicated, their source will be speculated upon. This should provide a basis to judge whether the models being evaluated do have "structural" validity and might therefore warrant further more rigorous testing to determine the accuracy of their predictions, or whether they are worthless for making predictions determined directly by the structural relationships underlying them. Where further testing is to be undertaken, the factors revealed as possible sources of any discrepancies noted in this initial test should first be used to indicate appropriate modifications to the original models.

The analysis undertaken in this study may also lead to other specific or general recommendations for the use of these or similar models for making predictions.

---

[29]This is explicitly preferred by Stekler, op. cit., 1968, who says ". . . if the ex post extrapolations yield good predictions, more confidence could be placed in the model's ability to predict" and also by Meyer and Glauber, op. cit., and Fox, op. cit. Thiel, Zarnowitz, op. cit., and Schmitz and Watts, op. cit., all recognize this preference implicitly by using data after the original sample period in some of their testing.

The Models.--In an attempt to fulfill the above objectives it is proposed to evaluate the models presented in two prize-winning studies[30] which deal with the use of aggregate time-series data to analyse supply and demand responses in agriculture. Both studies claim to arrive at models which are at least largely structural and which were also claimed to be useful for predictive purposes.[31] However, consistent with the most efficient use of the limited data available, especially as is usually the case with time-series economic data, it was all used in the estimation of the regression coefficients of the explanatory variables of the models and their variances. This left no independent data with which to test the models.

The first study deals with the burley tobacco industry.[32] Three models were used to describe a planting stage, a growth and harvesting stage, and the auction stage. The second study dealing with the Michigan dry bean industry[33] was described by three models similar to those used in the first study. The models for the first study will be described in more detail in Chapter II and Chapter III explains the Michigan dry bean models.

---

[30]Each study won the American Farm Economics Association (now the American Agricultural Economics Association) aware for outstanding published research reports. One in 1953 and the other in 1956.

[31]It should be noted that the major purpose of the Michigan dry bean study was an ex post evaluation of government programs.

[32]Glenn L. Johnson, Burley Tobacco Control Programs--Their Overall Effect on Production and Prices, 1933-1950, Bulletin 580, (Lexington, Kentucky: Kentucky Agricultural Experiment Station, February, 1952).

[33]Dale E. Hathaway, The Effect of the Price Support Program on the Dry Bean Industry in Michigan, Technical Bulletin 250, (East Lansing: Michigan Agricultural Experiment Station, April, 1955).

The Evaluation Procedure

In keeping with the objectives outlined above the first test will be a preliminary determination as to whether or not the models might give rise to verifiable predictions arrived at by a verifiable procedure.[34] The conditions that determine a verifiable procedure will be: 1) that in principle the prediction can be right or wrong (this excludes trivial predictions), and it must be possible to conclude with no ambiguity which, after a certain time; 2) that the concepts used must be well defined; 3) that a similar requirement regarding time or time interval is satisfied, and further, that the distance between the time (or time interval) and the moment of prediction should be finite; 4) that probability statements can be made on the relation between the forecast and the actual value, particularly for point predictions.

The conditions which determine a verifiable procedure[35] are: 1) that the line of thought by which the prediction is arrived at exists; 2) that it can be understood by persons other than the forecaster himself; 3) that these people agree that the procedure is reasonable even though they themselves may prefer another line of attack.

The implication of the last three conditions is that the forecast must be based on certain data and certain theoretical considerations. As will be seen, all the models evaluated in this study are

---

[34] See pp. 3 and 4 above.

[35] This ensures that a forecast, even though it meets the verifiable prediction criteria, is not merely a product of the forecaster's imagination.

based on economic theory. In addition, all but one of the models[36] is a regression equation or a system of such equations fitted by indirect least squares techniques. In order to give rise to sensible results, this procedure requires certain assumptions to hold at least approximately. These assumptions involve the behavior of the phenomenon being studied so that they also become economic assumptions.

This means that it must be verified, according to the theory used, that the aspects to be explained do depend on certain hypothesized explanatory variables, which do behave in the manner postulated by the economic theory. Further, it must be seen that those aspects assumed to be constant remain constant, and that those aspects not explained by the theory, i.e. the disturbance term, ξi, can be expected to behave in a certain manner.

The specification of the regression model then involves a dependent variable, one or more explanatory variable(s), a constant term, an unexplained stochastic disturbance, and the following basic assumptions which are taken to apply to all observations. These are that the disturbance term has: 1) a normal distribution; 2) zero mean; is 3) homoskedastic; 4) nonautoregregressive; that 5) the explanatory variables are nonstochastic; 6) the number of observations exceeds the number of coefficients to be estimated; and 7) no exact linear relationship exists between any of the explanatory variables.[37]

This provides an initial reference point to ensure that valid estimators with desirable properties are obtained from the data. These

---

[36]See Chapter II, The Burley Tobacco Study, The Underplantings Model.

[37]See Jan Kmenta, Elements of Econometrics, (New York: Macmillan Company, 1971), pp. 347-349.

estimates can then provide a basis for verifiable predictions since the procedures at least are verifiable. Departures from these assumptions may, in certain cases, be allowed for so that at least some desirable properties of the estimators will be retained, providing of course the departures are recognized. Locating any such departures is thus an essential part of the evaluation of the models in this study.

Since the structural validity of the models has been stressed at this stage, rather than the accuracy of data available at the time of forecast, an ex post rather than ex ante analysis will be used. Thus the test procedures used will be to follow the guidelines outlined above using the forecast errors[38] produced by the original equation to 1) indicate possible departures from the relationships and assumptions specified in the models. 2) Where departures occur an attempt will be made to speculate on the cause. a) In the first instance it will be an investigation to determine to what extent this might be due to factors explicitly indicated in the studies as a potential source of such variation. b) Secondly, other factors which might be responsible for the errors will be considered. c) In both cases an important aspect will be whether or not information which might have indicated the departure from the specified relationships to the forecaster would have been available at the time the forecast was made.

---

[38] In this case forecast errors are defined as the actual value of the dependent variable, A_i, less the value predicted for that variable, P_i, using the original model estimated.

Outline of the Study

This chapter then has indicated the need for structural models that can be used to give accurate "scientific" forecasts.[39] It identified an apparent lack of evaluation of models for this purpose in agriculture, although a survey of the literature indicated that appropriate theory and techniques are available. The objectives of this study were then set out and placed in general perspective and the evaluation procedure to achieve the objectives outlined.

Chapter II briefly describes the burley tobacco models, and the data used to test them including, where necessary, the derivation of this data and finally the analysis and results for the models.

Chapter III is a similar presentation dealing with the Michigan dry bean models.

Chapter IV summarizes the general conclusions obtained from the evaluation of the models.

---

[39] See above p. 4 for definition.

CHAPTER II

THE BURLEY TOBACCO MODELS[1]

Briefly, the burley tobacco study was undertaken,

> . . . to gain for the people of the burley industry a better understanding of how the control programs function economically and to acquire the ability to predict production and price effects of the control programs.[2]

Knowledge of three stages in the production and marketing of burley tobacco were considered essential to the attaining of this objective. These were the planting stage, the growth and harvesting stage, and the auction stage. The three econometric models which were developed to represent these stages were respectively, the underplantings model, the yield model, and the auction model.

In this Chapter each model will be taken in turn and described in more detail. The data used to test the model, and their derivation will be outlined where they are not merely a continuation of a published official series that was used in the original estimation of the parameters of the model. The model will then be evaluated in the manner described in Chapter I,[3] emphasizing the validity or lack of validity of the structural relationships specified in the models.

---

[1]Johnson, Burley Tobacco Control Programs, *op. cit.*

[2]*Ibid.*, p. 80.

[3]See above p. 15 ff. especially p. 17.

1. The Underplantings Model[4]

The planting stage in which the acreage planted in burley tobacco is determined is,

> . . . highly important in the success or failure of the control programs; in fact, control of acreage planted has been the primary method of supporting prices.[5]

This stage was represented by the underplantings model.

The Model

This model consists of a linear equation of three explanatory variables. The disturbance term, μ, was known to be dependent upon a number of social and technical factors of such importance as to make it invalid to assume that μ behaved according to any simple probability distribution. The estimates of the parameters were made using ordinary least squares procedures with graphic subjective modification to allow for the influence of certain of the factors contained in μ.[6]

The equation was fitted to data for the years 1937-1942 and 1944-1949, data for the years 1935, 1936 and 1943 being strongly affected by some of the factors included in μ. This gave twelve observations and eight degrees of freedom for estimating variances. However, since the basic assumptions on which such computations are based are not realized in this case, their estimates were not given since it would be difficult to know how to interpret them.

---

[4] Johnson, Burley Tobacco, op. cit., pp. 30-44 and Appendix B, pp. 105-106.

[5] Ibid., p. 27.

[6] Ibid., see graphs p. 41.

The model then is,

$Y_1 = f(X_1, X_2, X_3) + \mu$ with coefficients of X_1, X_2, X_3 to be read from the appropriate graph.[6]

Y_1 = national underplantings = U.S. national allotment less harvested acreage (endogenous). (Measured in thousands of acres).

X_1 = real price of burley = the lagged U.S. season average price deflated by the index of prices paid for items used in production (including labor) on a typical, area-type, central Kentucky burley tobacco-livestock farm. (Regarded as exogenous, as the price of burley used is lagged and the level of prices paid is governed largely by factors external to the burley economy). (Measured in cents per pound).

X_2 = U.S. allotment of burley less average acreage of burley harvested in the preceeding six years (exogenous). (Measured in thousands of acres).

X_3 = total penalty per first acre of overplanting per farm (exogenous). (Measured in dollars per acre).

The Data

The data for U.S. national allotments, annual harvested acreage and U.S. season average price of burley (hence forth allotments, harvested acreage, and price respectively), for the years 1950-1970, are available from various official sources and are given in Table 2.11 together with their respective source(s).

The index used in this study to represent prices paid for production items (including labor) on a typical area-type, Kentucky, burley tobacco-livestock farm, is the equivalent index for the

TABLE 2.11.--BURLEY TOBACCO, UNDERPLANTINGS "MODEL": DATA USED, PREDICTIONS OBTAINED, UNITED STATES, 1935-1970.

Year	National Underplantings Burley Tobacco: Actual[a]	National Underplantings Burley Tobacco: Predicted[b]	Real Price of Burley[c]	Index of Prices Paid[d]	Total Penalty for Overplanting[e]	Allotment Less Normal Acreage[f]	National Burley Allotment[g]	Harvested Acreage[h]
	(1000 acres)		(Cents per lb)	(1930-34=100)	($ per acre)	(. . . 1000 acres . . .)		
1934			19.9					
1935	13.5		21.2	85	86.8	-141.4	293.3	279.8
1936	61.9		37.2	90	39.6	-47.2	364.4	302.5
1937	-50.1		21.8	96	43.2	9.6	392.9	443.0
1938	40.7		20.9	92	136.5	74.3	447.8	407.1
1939	-17.5		18.8	91	66.6	34.3	407.2	424.7
1940	14.3		15.4	92	107.6	14.4	374.6	360.3
1941	39.6		24.1	105	120.8	11.9	381.5	341.9
1942	31.7		30.3	121	113.9	2.4	382.3	350.6
1943	71.2		28.9	138	116.6	82.6	470.5	399.3
1944	92.2		28.2	158	121.0	208.2	588.8	496.6
1945	98.4		23.9	156	146.1	215.1	610.7	512.3
1946	68.3		21.7	165	201.6	147.2	557.3	489.0
1947	48.6	48.6	25.0	183	220.8	37.0	468.6	420.0
1948	31.2	40.9	22.1	193	241.8	19.6	468.2	432.0
1949	20.9	40.4	21.7	208	279.6	10.2	468.3	453.4
1950	9.9	19.9	22.3	206	244.1	-48.3	418.3	408.3
1951	16.0	42.6	22.7	220	258.6	19.7	472.2	456.1
1952	11.2	47.5	22.3	226	298.4	31.6	474.7	463.5
1953	13.0	34.9	22.7	226	301.8	-6.1	432.7	419.7
1954	-21.5	14.0	21.7	232	303.5	-39.4	399.5	420.9
1955	-1.3	-6.3	25.3	230	331.9	-127.7	309.3	310.6
1956	-1.1	-1.7	26.3	232	680.5	-104.5	308.7	309.8
1957	2.0	2.8	25.0	242	796.6	-88.1	308.6	306.6
1958	11.7	13.2	26.5	242	744.1	-63.0	308.9	297.1

1959	8.1	21.6	24.1	250	792.8	-35.0	309.1	301.0
1960	13.7	31.1	25.4	252	775.6	-14.1	295.7	
1961	9.7	43.8	26.2	254	808.3	26.0	318.9	
1962	10.0	48.9	22.6	254	928.9	44.6	338.6	
1963	10.4	51.1	22.6	259	899.1	40.1	338.5	
1964	9.1	38.5	22.4	261	1014.1	1.6	306.6	
1965	9.5	27.9	24.3	269	934.1	-29.1	277.1	
1966	9.2	13.9	23.6	275	1081.4	-61.7	240.7	
1967	12.5	18.1	24.7	283	1243.9	-52.6	237.4	
1968	12.4	22.1	24.5	291	1244.5	-39.0	237.6	
1969	12.1	27.8	22.0	301	1332.1	-22.3	237.7	
1970	14.2	29.8		317	1319.1	-24.3	216.7	

[a]Col. 1. Underplantings of the national burley allotments: computed as the U.S. national burley allotment (see Col. 7) less harvested acreage of burley (see Col. 8).

[b]Col. 2. Predicted underplantings: read from the graphical relationships of the model; see Johnson, Burley Tobacco, op. cit., p. 41, Figure 11.

[c]Col. 3. The real price of burley: computed as the U.S. average season price of burley, (see below, Table 2.21, Col. 3), divided by the index of prices paid (see Col. 4), 1935-70.

[d]Col. 4. Index of prices paid for items used in production (including labor) on a typical area type, central Kentucky burley-livestock farm: 1935-44; see Johnson, op. cit., p. 105; 1950-70, see text pp. 20-23, especially footnote 7.

[e]Col. 5. Total penalty for the first acre of overplantings: 1935-44, see Johnson, op. cit., p. 11, Table 1; 1945-1954, see ibid., footnotes i and j; 1955-70, see text, p. 23.

[f]Col. 6. U.S. national burley allotment less normal acreage: computed as current allotment (see Col. 7) less acreage harvested for the previous 6 years, 1935-70.

[g]Col. 7. U.S. national burley allotments: from Johnson, op. cit., work-sheets, 1935-39; USDA, ASCS, Tobacco Division, Tobacco Acreages Alloted by States and Kinds 1940-1970, (Washington, D.C.) 1940-70.

[h]Col. 8. Annual harvested acreage of burley tobacco: from USDA, Agricultural Statistics, (Washington, D.C.: U.S. Government Printing Office, various annual issues), 1935-70.

Intermediate Bluegrass Region. It was chosen because it seemed most representative of the typical (average), area-type, tobacco-livestock farm in this region and it avoided discontinuities that would have occurred in the data series.[7]

Data for total penalties per first acre of overplanting were computed on the same basis as the original data until 1955.[8] In this year the penalty rate for marketings in excess of the quota was increased from 40 per cent to 50 per cent of the previous year's average market price. This was increased again in 1956 to 75 per cent.[9] The new penalty rates were accordingly used to calculate the values for the total penalties for these and later years.

---

[7]The original indices were computed on the basis of three farm size groups, large, small, and medium, with an index also representing the average area-type farm. A new set of indices based on the three geographic areas of the Bluegrass Region, Inner, Intermediate and Outer, which respectively correspond approximately to the farm size groups above, were started in 1945 together with an index for the area-type farm. These indices ran concurrently with the old series until 1949 when the latter were discontinued. The average area-type index on the new basis was stopped in 1958 and the others in 1968 pending revision. (These comments are based on personal correspondence with Dr. H. Bondurant, Professor Emeritus of Agricultural Economics, Kentucky University, Lexington, September 2, 1971.) Because the difference between the two typical area-type indices and also the Intermediate area index were small (much less than 3 per cent except in 4 years for the period 1945-1968), the last index was chosen and spliced to the original typical area-type series using the years 1945-1949. The years 1969 and 1970 were extrapolated using the changes in the U.S. parity index as a guide.

[8]See Johnson, Burley Tobacco, op. cit., p. 11, Table 1 and footnotes.

[9]See U.S.D.A., Commodity Stabilization Service (now A.S.C.S.), Compilation of Statutes Relating to Soil Conservation, Marketing Quotas and Allotments, etc. as of January 1, 1961, Agricultural Handbook No. 192, (Washington, D.C.: U.S. Government Printing Office, 1961) p. 41 and Ibid., Agricultural Handbook No. 361, 1969, p. 51.

Testing the Model

In this section the underplantings model will be evaluated according to the procedure outlined in Chapter I.[10]

Verifiable Predictions.--The objective is a preliminary check to see whether or not the conditions for verifiable predictions are or might be met.

The first condition is sustained. The value predicted for the dependent variable, underplantings, is the forecast for a real world event. Its actual value, if the final U.S.D.A. estimate is accepted as this, can be observed with "accuracy" at least within two years of the event. The prediction, with its error limits,[11] can therefore be verified as right or wrong.

The second condition also appears to be fulfilled since the variables are all defined according to well recognized concepts.[12] It is less clear, however, whether condition three involving the time concepts used is met or not. The planting stage in which underplantings are considered to be determined is well defined, i.e. the 4-1/2 to 5 months from the end of January to the middle or end of June. However, a survey of the Tobacco Situation Reports[13] indicate the final estimate for underplantings, or harvested acreage upon which it depends, is not arrived at until from anywhere between 9 and 18 months from the end of

---

[10]See above pp. 15-17.

[11]Providing condition four below is also met.

[12]See the definition of the variables above, p. 21.

[13]U.S.D.A., Economic Research Service, Tobacco Situation, various quarterly issues.

the planting stage. Thus a prediction to be useful in this case would not have to be made before the end of the planting stage. It would merely be required to be a more accurate prediction, at a given date, than the preliminary U.S.D.A. estimates. To evaluate whether this was the case would require an ex ante analysis and is beyond the immediate objective of this study. It is therefore merely noted that reasonably reliable estimates of the explanatory variables (generally within 1 per cent of the final actual value) are available for predicting underplantings at least by the end of September for the year being forecast, and, with less accuracy, as early as April or even March, with one possible exception.

The exception is the index of prices paid used in determining the real price of burley. It is defined as the value for the current year which is therefore not known until after December. A more realistic approach, if the model is to be used for predictive purposes, would seem to be to use the average value of the index for the 5 months covering the planting stage. It might be either the actual value of the index for these months or the annual value for the previous year extrapolated using perhaps the U.S. parity index, which is computed on a monthly basis as a guide. Once this is accounted for, however, it would appear that this third condition for verifiable forecasts can reasonably be met.

The fourth condition requires that a probability statement should relate the forecast to the actual value, particularly in a case such as this, where the model is making point forecasts.[14] As was noted

[14]A point has no area and therefore the probability of it occurring is zero if a strictly theoretical approach is used.

above in describing the model, the conditions for making useful estimates of variance obviously do not hold in this case. This means that individual confidence intervals for the forecasts cannot be determined. It was noted in the original study that the estimates of underplantings fell within bounds of 37,000 acres of the actual value 95 per cent of the time or 18,500 acres two-thirds of the time.[15] This value would be wider for forecasts and the fact that it is the same regardless of the size of the explanatory variables and thus the dependent variable, underscores its inefficiency as a confidence interval. It does mean, however, that the fourth condition for verifiable forecasts is met, for what that is worth.

Verifiable Forecast Procedure.--Whether or not the procedure by which the forecasts are arrived at are verifiable is the next criterion to determine whether the models give rise to scientific forecasts based upon structural concepts.

Initially, at least, from the description of the model above, the three conditions given in Chapter I which would give it that property appear to be met. The description shows the model to be based on explanatory variables suggested by production theory, and that there are data available for these variables. In addition the specification of the model appears to be validated by the initial testing of it by its author. His qualification was that an estimate or forecast must be interpreted with consideration for the special

---

[15] See Johnson, Burley Tobacco, op. cit., p. 42, footnote 1.

conditions existing in that year,[16] i.e. conditions not accounted for by the explanatory variables.

A more stringent test of whether the forecast procedure is verified, particularly with respect to its structural specification, is to test it on an ex post basis for some period after that in which it was fitted. Using this method, if the forecast errors remain of essentially the same size and pattern as the residuals,[17] there will be then much greater certainty that the behavioral aspects in the planting stage, which determine underplantings, have been correctly represented (specified) and measured by the model.

The forecast errors for the underplantings model for the period 1950-1970, together with the residuals for the period in which the model was fitted, 1937-1949, are shown in Figure 2.11. Forecast and actual values for underplantings are illustrated in Figure 2.12. The pattern of the forecast errors is strongly suggestive of an autoregressive disturbance entering the system. However, the values of the explanatory variable, which is the difference between current allotment and "normal"[18] harvested acreage, shown in Table 2.11, appear to be closely related to the size of the forecast errors.

Indeed, when the forecast errors are arranged according to the size of this variable rather than chronologically, the existence of a relationship is even more strongly suggested. This is illustrated in Figure 2.13 where the errors are shown in relation to the original

---

[16] _Ibid._, pp. 42-44.

[17] This is the difference between estimated and actual value for the dependent variable in the sample.

[18] "Normal" refers to the average acreage harvested in the previous 6 years.

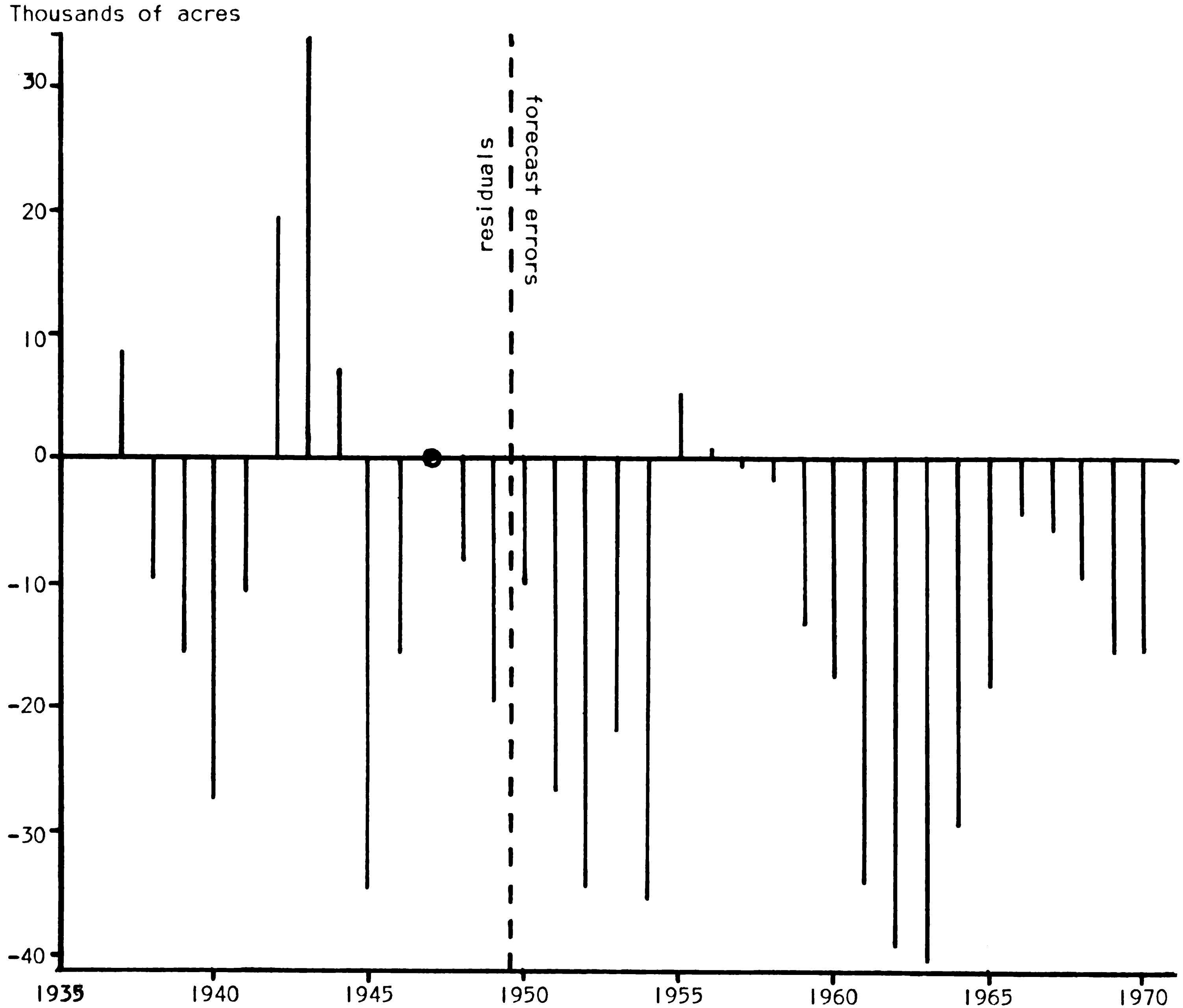
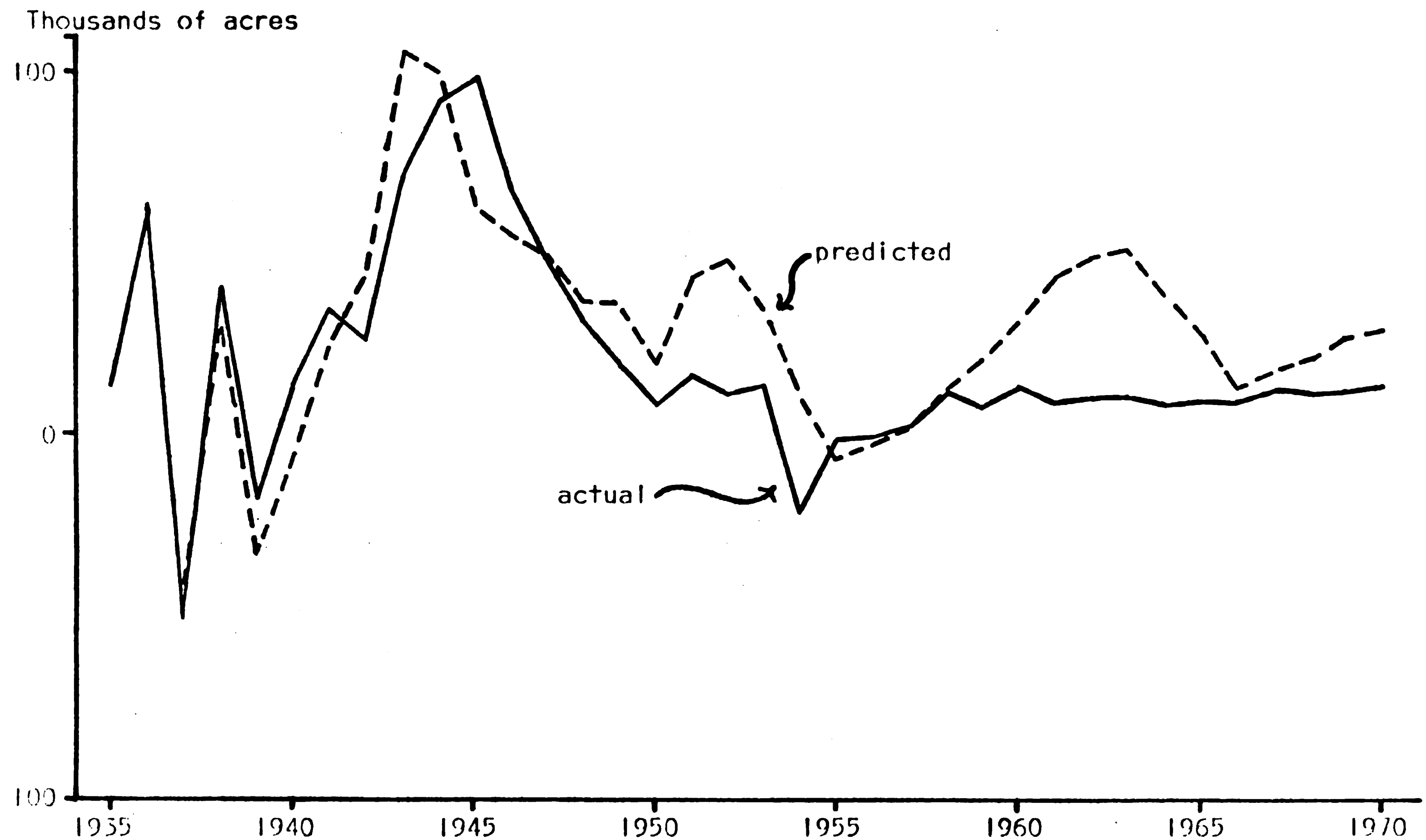
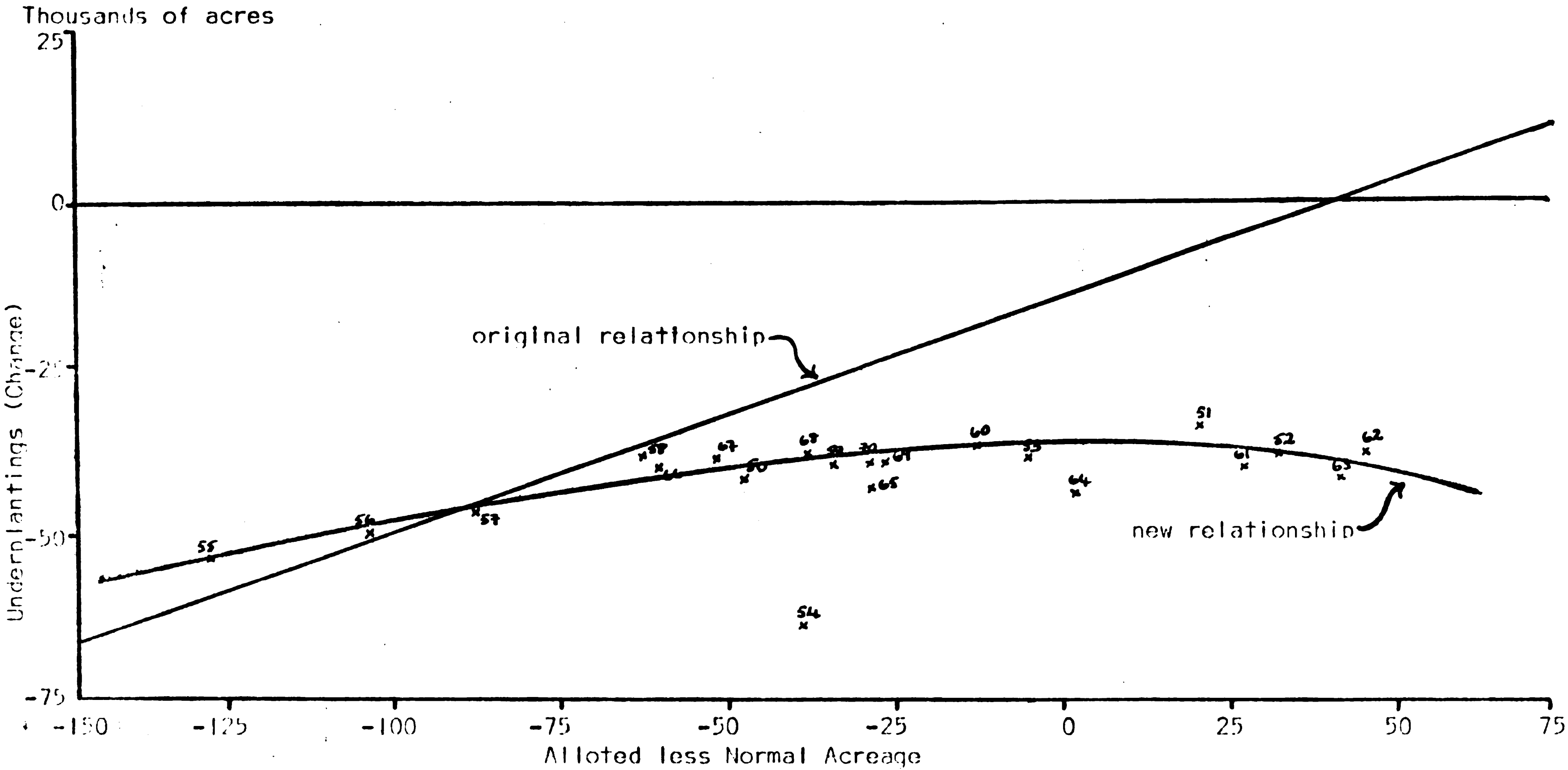


FIGURE 2.11 -- Burley tobacco, underplantings model: residuals 1937-1949 and forecast errors 1950-1970.



Source: see Table 2.11.

FIGURE 2.12 --Underplantings of burley tobacco, United States, actual 1935-1970 and estimated 1937-1970.



Source: see Table 2.11 and Johnson, Burley Tobacco, op. cit., p.41, Fig.11.

FIGURE 2.13 -- Relationship for changes in underplantings to difference between U.S. allotments and normal acreage: old relationship 1937-1949 and new 1950-1970.

linear relationship estimated between this variable and underplantings. As shown in this figure, an excellent fit (apart from one major departure in 1954) was obtained when a new relationship was fitted for the years 1950-1970, by a subjective graphical procedure.[19]

If correct, it indicates that the effect of changes from normal acreage on underplantings has become much weaker than it used to be. It is also curvilinear rather than linear as the old relationship was. The theoretical basis for the change would appear to be largely due to the effects of the control program which caused changes in the size and distribution of allotments.

The apparent explanation for the large error in 1954 gives additional weight to the validity of the new relationship. It primarily appears to have been due to an increase of approximately 7,000 allotments over the number in 1953, to an all time high of 317,000 allotments. This had the effect of more than offsetting the announced cut in acreage allotments of 8 per cent for that year. This meant that instead of the 399.5 thousand acres of allotment announced for 1954 and an estimated harvested acreage of 403.7 thousand acres, harvested acres were 420.9 thousand which equals the approximate redetermined allotted acreage quota. Taking this into account the forecast error is reduced to about +3.5, which is within the error bounds for the new relationship.

---

[19]The standard error for this fit, 1950-1970, is 2.7 if the error in 1954 is excluded, 5.9 when included, compared with a standard error of 23.4 for the forecasts obtained using the original relationship, and 19.9 for the period 1937-1949. The new relationship also removed all bias for the 1950-1970 period which was large and negative using the old relationship.

Assuming the new relationship is correct, then the forecast errors would indicate much less variability in the period 1950-1970, and especially 1960-1970, then previously was the case. This is no doubt due largely to improvements in the administration of the control program. Evidence for this conclusion is the reduction in the fluctuations of the real price of burley (see Table 2.11) in the period 1950-1970. This appears to be obtained from experience in operating the control program supplemented with modifications to regulations, for example the changing of the basis on which support price was determined in 1960.[20] Similarly legislation in 1955 and 1956 increased the penalties for overplanting.[21] At the high levels of penalties[22] this legislation gave rise to, however, they had little additional effect on the level of underplantings, as the asymptotic properties of relationship estimated by Johnson would suggest.[23] However, as was observed above, it has contributed to a decrease in the variability of underplantings.

Finally, a forecaster using the model should certainly have been acquainted with the new legislation. Experience with the behavior of the industry in previous years as captured by the model and examination of the data for those years should have led him to expect a decrease in the variance associated with underplantings. For this reason and also

---

[20]Agricultural Act of 1949 as Amended, approved October 31, 1949, 63 Stat. 1051, especially Sec. 106 added February 20, 1960, 74 Stat. 6, see USDA, ASCS, op. cit., 1969, p. 160.

[21]See above, p. 24 and footnote 9.

[22]See total penalties, Table 2.11.

[23]See Johnson, Burley Tobacco, op. cit., p. 41, Figure 11.

the close relationship that appeared between the size of the forecast errors and the values of the variable for the current allotment less normal acreage effect, it seems reasonable that the forecaster might have been quick to discover this change of relationship. In fact, with the wide range in the values for this variable it is possible the new relationship could have been estimated with considerable accuracy within 3 to 4 years after the change occurred.[24]

Summary

From this preliminary examination it does appear that the original model was correctly specified to explain the relevant behavior of the variable, underplantings, of interest in the planting stage. For this reason it helped indicate the change in behavior that appears to have occurred in 1949 or 1950. When this change is incorporated in the specification of the model it would seem to give rise to accurate forecasts. The values of these forecasts show much less variability than in the 1937-1949 period. This is taken to be indicative of the effect of the control program and improvements in its administration.

In the closely controlled environment this brought about, it should be emphasized that the model, because of its structural nature, was useful in pointing up the manner in which reductions in variability become effective, since, with regard to making accurate predictions, it will be noted from observing actual underplantings in Figure 2.12, that it would have been difficult for any model to have made more accurate predictions than a naive model making forecasts on the basis

[24]See the values for 1949, 1950, 1951 and 1952, Figure 2.13.

of no change from the previous year. This would have especially been the case since 1961.

Thus the model is taken to represent a verifiable prediction procedure. It also appears that the predictions are verifiable with qualifications with respect to the definition of the time when the prediction would be made, and the efficiency of the confidence limits for predictions. The possibility of redefining the index of prices paid was suggested with regard to the first matter. In the second, a new estimate of variance is required. The consequence would undoubtedly be a much smaller error for a given level of certainty than previously.

In conclusion, it would appear that the model might warrant further testing on an ex ante basis once the changes mentioned above are incorporated into the model, to determine the accuracy of its forecasts when based on data that would be available at the time when the forecast is made. It is suggested that a useful standard with which to evaluate the usefulness of the model's predictions might be the forecasts of underplantings made for the Tobacco Situation at various intervals before, during, and after the planting stage.

2. The Yield Model[25]

In the growth and harvesting stage the yield of burley is determined. Yield in combination with the acreage determined in the planting stage determines production, which in turn becomes an important component of the supply disappearance and hence price picture. This stage was represented by the yield model.

---

[25]Johnson, Burley Tobacco, op. cit., pp. 44-56 and Appendix B, pp. 106-108.

The Model

This model is a regression equation with five explanatory variables, fitted by ordinary least squares procedure using data from the years 1935-1949. This gave 15 observations and thus 9 degrees of freedom with which to estimate variance. The equation is as follows:

$$Y_1 = \underset{(200.31)}{312.25X_1} - \underset{(8.32)}{14.94X_2} + \underset{(12.93)}{59.62X_3} - \underset{(0.25)}{0.3672X_4} + \underset{(2.19)}{6.63X_5} + 170.7$$

$$R^2 = 0.9423$$

Y_1 = U.S. average yield of burley (endogenous). (Measured in pounds per acre.)

X_1 = Log. of lagged U.S. season average price of burley. Lagged, endogenous and hence, predetermined and independent. (Cents per pound.)

X_2 = Square of index of prices paid for items used in production (including labor) on a typical small, livestock-burley farm, central Kentucky (assumed exogenous). (Per cent of 1930-1944.) The square is divided by a thousand.

X_3 = Time. (Years, 1942 = 0.)

X_4 = Current year's U.S. national burley allotment less average acreage harvested in preceding three years (exogenous). (1000's of acres.)

X_5 = Index of influence of weather on burley yields (exogenous). (Normal = 100.)

The author interpreted the model as being structural but noted certain qualifications. These were that while the disturbance term was assumed to be random and normally distributed, in certain years there would be factors (he noted 6 explicitly) which would make this assumption unrealistic[26] and that forecasts from this model should be adjusted for these factors in years when they are important. There is also a high correlation between the explanatory variables X_1, X_2 and X_3, which greatly reduces the reliability of their regression coefficients, and which means that the disturbances are not randomly and independently distributed amongst these three variables. It was concluded that the influence of trend is overestimated, that the effect of increases in prices paid is also overestimated, and that the influence of increase in burley prices is "somewhat" overestimated.

The Data

The data for the price, national allotment and harvested acreage of burley are the same as used for the underplantings model above.[27] The cost index used was also the same as used for that model, because as noted above[28] the index for the Intermediate area of the Bluegrass Region corresponds approximately to the original index for a typical, small tobacco-livestock farm in Central Kentucky. In this case, of course, it was spliced to the latter index rather than the typical area-type index that was used originally in the underplantings model. The resulting composite index is given in Table 2.21.

For the weather index, yields of burley tobacco from experimental check plots from which the original index was calculated, could not be obtained on a similar basis for the period 1950-1970. Instead,

---

[26]See Ibid., p. 107.

[27]See Tables 2.11 and 2.21.

[28]See discussion above, pp. 23 and 24 and especially footnote 7.

TABLE 2.21.--BURLEY TOBACCO, YIELD MODEL: DATA USED, PREDICTIONS OBTAINED, UNITED STATES, 1935-1970.

Year	Average Yield of Burley Tobacco (lbs per acre)		Price of Burley[c] (Cents per lb)	Index of Prices Paid[d] (1930-34=100)	Allotment less Normal Acreage[e] (1000 acres)	Weather Index (Normal=100)		Average Allotment[h] (Acres)	Number of Allotments[i] (1000)
	Actual[a]	Predicted[b]				Original[f]	Present[g]		
1935	794	777	19.1	91	-111.6	109			
1936	729	729	35.7	89	2.8	96			
1937	907	854	20.1	95	7.7	96			
1938	833	911	19.0	93	105.9	112			
1939	931	935	17.3	90	22.9	102			
1940	1045	1018	16.2	94	-50.4	105	101.5	1.560	239.7
1941	985	923	29.2	99	-21.7	87	98.4	1.530	244.7
1942	980	1040	41.8	112	3.1	91	94.7	1.542	245.6
1943	982	1047	45.6	126	119.6	90	97.4	1.895	248.2
1944	1189	1146	44.0	140	224.9	108	102.8	2.336	252.1
1945	1127	1080	39.4	143	195.2	90	100.0	2.285	266.5
1946	1256	1220	39.7	150	87.9	103	104.3	2.044	272.7
1947	1153	1207	48.5	169	-30.7	99	93.7	1.697	276.2
1948	1396	1370	46.0	172	-8.5	114	111.8	1.648	281.0
1949	1305	1311	45.2	176	23.4	102	95.4	1.616	289.9
1950	1222	1286	49.0	186	-16.9		95.6	1.401	298.5
1951	1355	1302	51.2	197	40.9		99.8	1.563	302.2
1952	1403	1350	50.3	202	35.5		101.7	1.542	307.9
1953	1345	1379	52.5	202	-9.9		94.9	1.391	311.1
1954	1586	1511	49.8	207	-47.0		107.7	1.260	317.0
1955	1513	1548	58.6	206	-125.4		99.4	1.006	307.4
1956	1635	1613	63.6	207	-75.0		101.3	1.024	301.3
1957	1592	1604	60.3	216	-38.5		99.7	1.024	301.4
1958	1567	1594	66.1	216	-0.1		92.4	1.022	302.2
1959	1669	1651	60.6	223	4.6		97.5	1.021	302.8
1960	1639	1651	64.3	225	7.8		92.2	1.023	302.3
1961	1820	1746	66.5	227	30.7		99.5	1.093	300.6

1962	1993	1842	58.6	227	43.4		105.1	1.158	301.1
1963	2231	1934	59.2	232	31.2		117.3	1.164	299.8
1964	2022	1827	60.3	234	-19.3		91.0	1.057	298.6
1965	2116	1822	67.0	241	-41.3		87.2	.970	295.4
1966	2437	2027	66.9	246	-57.5		112.1	.854	292.5
1967	2274	1910	71.8	254	-24.9		95.1	.868	288.1
1968	2372	1956	73.7	261	-1.8		101.0	.878	284.8
1969	2488	1990	69.6	269	11.2		107.2	.883	282.9
1970	2585	1938	72.2	284	-6.6		109.1	.819	282.1

[a]Col. 1. Average annual of burley tobacco per harvested acre: USDA, Agric. Stat., op. cit., 1935-70.

[b]Col. 2. Predicted yield of burley: computed using the yield model, see above, p.

[c]Col. 3. U.S. average season price of burley tobacco: USDA, Agric. Stat., op. cit., 1935-70.

[d]Col. 4. Index of prices paid for items used in production (including labor), typical small, livestock-burley tobacco farm, central Kentucky: see Johnson, op. cit., p. 106, 1935-49, and see text p. 1950-70.

[e]Col. 5. U.S. national burley allotment less normal average (normal average = average harvested acreage for previous 3 years); see Table 2.11, footnote Col. 6, 1935-70.

[f]Col. 6. Original weather index: computed from check plot yields for burley tobacco from Johnson, op. cit. worksheets, and also text p. , 1935-49.

[g]Col. 7. Present weather index: computed from country yield of burley tobacco; see text p.

[h]Col. 8. Average size of burley allotments: computed as national burley acreage allotment (see Table 2.11, Col. 7) divided by numbers of burley allotments (see Col. 9), 1940-70.

[i]Col. 9. Numbers of burley allotments: USDA, ASCS, Tobacco Division, Tobacco Number of Allotments by States and Kinds 1940-1970, (Washington, D.C.), 1940-70.

yields for the three counties from which the original test plot data were collected, were obtained, i.e. Fayette County, (Lexington, Kentucky), Taylor County (Campbellsville, Kentucky) and Greene County (Greenville, Tennessee) for the years 1940-1970.[29] Trend was removed from the data by taking the difference between the value in each year and a seven year moving average and expressing it as a percentage of the average yield for that county for the entire period. Now originally, the entire burley growing area was divided into three sub-regions as shown in Figure 2.21. Each sub-region was represented by one of the locations above. The total effect of weather on burley yield then, is the sum of the differences obtained above, each first weighted according to the proportion its sub-region represents of the total harvested acreage for burley,[30] added (or subtracted) from 100 or normal. The new index was spliced to the old using the years 1940-1949 (see Table 2.21).

As can be seen from inspecting the values based on county yields with the original values based on test plot yields, the former, while

---

[29]The data for the first two counties was obtained from personal correspondence with James M. Koepper, Agricultural Statistician in Charge, Kentucky Crop and Livestock Reporting Service, Louisville, Kentucky, July 29, 1971; for Greene County from personal communication with Mr. Hobson, Agricultural Statistician in Charge, Tennessee Crop Reporting Service, Nashville, Tennessee.

[30]Based on harvested acreage in 1940, 1941 and 1942, Area 1 represented by Fayette County had 57.6 per cent of total harvested acreage, Area II represented by Taylor County, 28.2 per cent, and Area III, represented by Greene County, 14.2 per cent (based on Johnson's worksheets for Burley Tobacco, op. cit.). In 1968 the respective proportions were 55 per cent, 30 per cent, and 15 per cent (from personal correspondence with Dr. D. Milton Shuffett, Dept. of Agricultural Economics, Kentucky University, July 15, 1971). The first set of proportions were used for the years 1940-1954 and the 1968 proportions for the years 1955-1970.

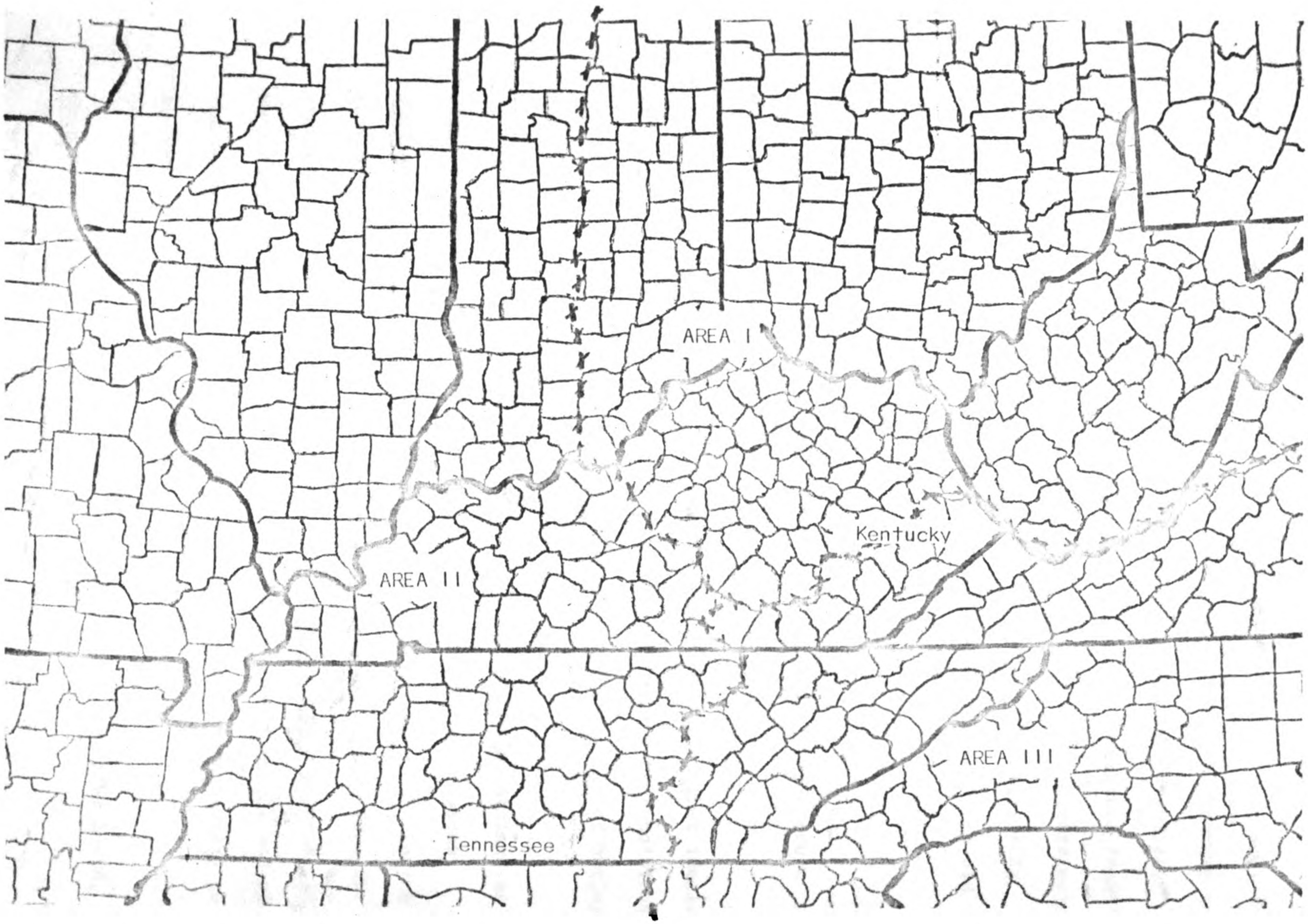


FIGURE 2.21 -- The main burley producing area showing the three subareas used in the construction of the weather index.

corresponding in general movement with the latter, shows less variation. It also appears likely that the new values are affected by changes in allotments in some years. The values do however appear to reflect weather conditions reasonably well as far as can be determined from annual weather conditions reported in Crop Production.[31] Accordingly, for this preliminary evaluation of the model, it will be initially assumed that the new weather index is fully comparable with the old one.

Testing the Model

The yield model is now evaluated according to the procedure established in Chapter I.

Verifiable Predictions.--It was found in Chapter I that ideally predictions should be verifiable. This requires that four conditions be met, in this case regarding the predictions of the yield of burley tobacco.

The first condition, that the prediction can be determined as right or wrong after a certain period of time is met for reasons similar to those given above for the underplantings model.[32] In the case of yield, the final estimates made by the USDA appear, from an examination of the Crop Production and Tobacco Situation reports, to be arrived at in anything from as little as 3 months from the end of the harvest season (approximately the middle to end of September) to as much as 12 months afterwards.

---

[31] USDA, Statistical Reporting Service, Crop Reporting Board, Crop Production, (Washington, D.C.: various issues).

[32] See above, p. 25.

With respect to the second condition, there would appear to be no room for confusion over the definition of the dependent or explanatory variables except for the trend variable. In this case as in most others, the trend variable is used as an approximation. It represents a number of factors (here involving technology, management and stability)[33] which are too complex and/or numerous to be adequately measured, or to be represented individually in the model. This is especially the case in time-series models. With no practical alternative available, however, it will be sufficient to merely recognize this deficiency. It is also recognized that using county yield statistics to compute the weather index is much less desirable than using test plot data. The latter are likely to be available more quickly and the former are liable to be confounded by changes in allotments, price effects, etc. However, they are considered adequate for this evaluation.

For the third condition, regarding the time intervals defined, there is some uncertainty as to what was intended. This was also noted above with respect to the underplantings model. From the definition of its variables, the model is obviously intended to make predictions of average annual yield. However, its author does not make it clear at what stage the forecast would be made.

The examination of the USDA estimates mentioned above indicate that the model might be used, if its forecasts were sufficiently accurate, to verify estimates of burley yield providing the forecast was made before March of the following year, i.e. about 6 months from

---

[33]See Johnson, Burley Tobacco, op. cit., pp. 55 and 56.

the time its determination was completed. By March reliable values for all the explanatory variables would be available.

However, it appears the model could be used as early as the end of September if the variable for the index of prices paid was redefined as a 6 or 9 months statistic instead of an annual one.[34] The data for the other explanatory variables are final by this time with only very rare exceptions.

When these considerations are taken into account the third condition is met.

The fourth condition, which requires the specification of a probability statement relating forecast to actual values of yield is fulfilled since estimates of variance were obtained, at least for the sample period.[35] It remains to be seen whether the conditions are likely to make these estimates meaningful for years outside this initial period.

Thus, initially at least, the condition for veriable forecasts of yield appear to be met. An ex ante evaluation of their accuracy is required to finally determine what their usefulness is likely to be to decision-makers, but this is outside the scope of this study.

Verifiable Forecast Procedure.--The other requirement of the forecasts was that they should be arrived at by verifiable procedures.

The conditions for a verifiable procedure were outlined in Chapter I and were demonstrated with respect to the underplantings

---

[34]See discussion for underplantings model concerning a similar variable, p. 26.

[35]See above, The Model, pp. 36 and 37.

model above. As for that model, they appear to be fulfilled by the yield model, at least for the period in which it was fitted.

This criterion will now be subjected to a more rigorous test and also modifications which might be required for future use and/or testing of the model will be speculated upon. The same procedure as used in the underplantings model will be followed.[36]

The forecast errors for this model from 1950-1970 and the residuals for the period 1935-1949 are illustrated in Figure 2.22. It appears that the initial specification of the structure of the growth and harvesting stage and the estimates of their parameters are valid for a period of 11 or possibly 12 years, i.e. until 1960 or 1961. At that point a very marked change occurs. It should also be noted that there appears to be a significant decrease in the variance associated with the forecast errors in 5 or possibly 6 years, 1955 or 1956-1960.

Johnson examined several factors which were not estimated in the equation but which were concluded to be largely responsible for the residuals.[37] The effect of these factors on the forecast errors will be considered here.

The negative residual in 1950, and to a lesser extent the one in 1953, coincides with increases in the number of allotments in spite of decreases in allotted acreage. This means that the general yield increasing effect of a decrease in allotments from normal acreage (measured by the average acreage harvested in the previous three years) is overestimated since, following Johnson's argument, the

---

[36]See p. 27.

[37]See Johnson, Burley Tobacco, op. cit., pp. 50-56 for a discussion of these factors and their effect on the residuals.

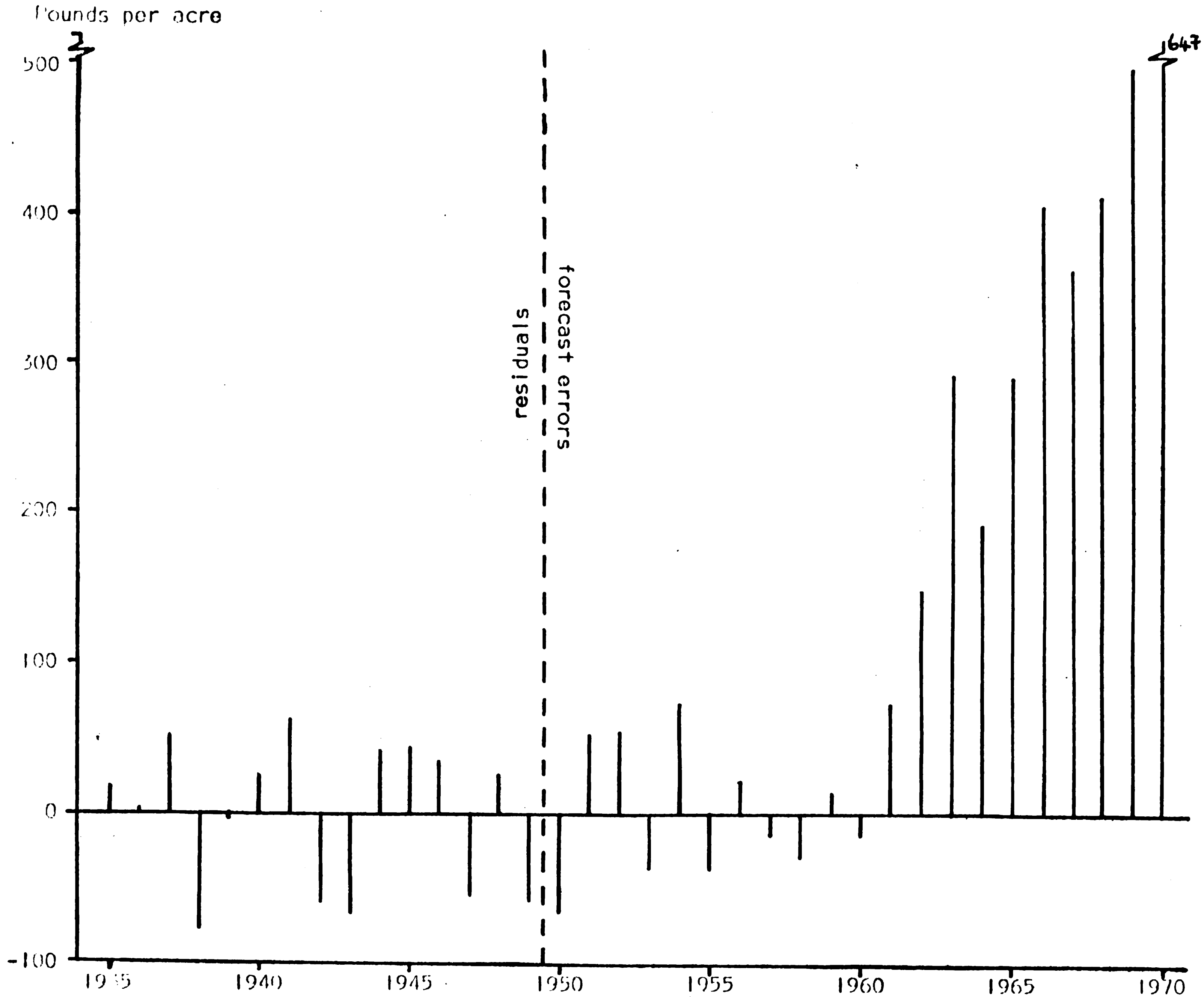


FIGURE 2.22 -- Burley tobacco, yield model: residuals 1935-1949 and forecast errors 1950-1970.

acreage of burley actually grown will be produced by generally poorer management on small farms, accentuated by the fact that the acreage has been spread to land less suitable for burley production.

The forecast errors in 1951 and 1952 appear to be due, at least partially, to the yield decreasing effect of increases of acreage over normal being overestimated because of an increase in the average size of allotments, which meant there was a redistribution of burley acreage back to better land and better managers. This was in spite of small increases in numbers of allotments.

The 1954 error appears to be due to the same factors discussed for the residual in this year in the underplantings model.[38]

The decrease in size of the forecast errors in the years 1955-1960 are speculated to indicate another change in the structure of the burley industry. It is thought to be due to a marked increase in the stability of allotted acreage, numbers of allotments and consequently the average size of allotments in these years.[39]

The reduction in the number of allotments was no doubt partially due to the low burley price in 1955. This caused new farmers on marginal land to go out of burley production and this was maintained in later years by the allotment system. A change in legislation in 1955 caused reductions in acreage allotments to be distributed more evenly amongst burley producers than had been the case since

---

[38]See p. 32.

[39]See Table 2.21.

1944.[40] Since 1944, large producers had borne most of the cut in acreage which had caused the proportion of burley produced by smaller farmers, who were generally poorer managers and farmed poorer land, to increase so that yield increasing effects were generally less than that specified by the model. Beginning in 1956 this effect was reduced.

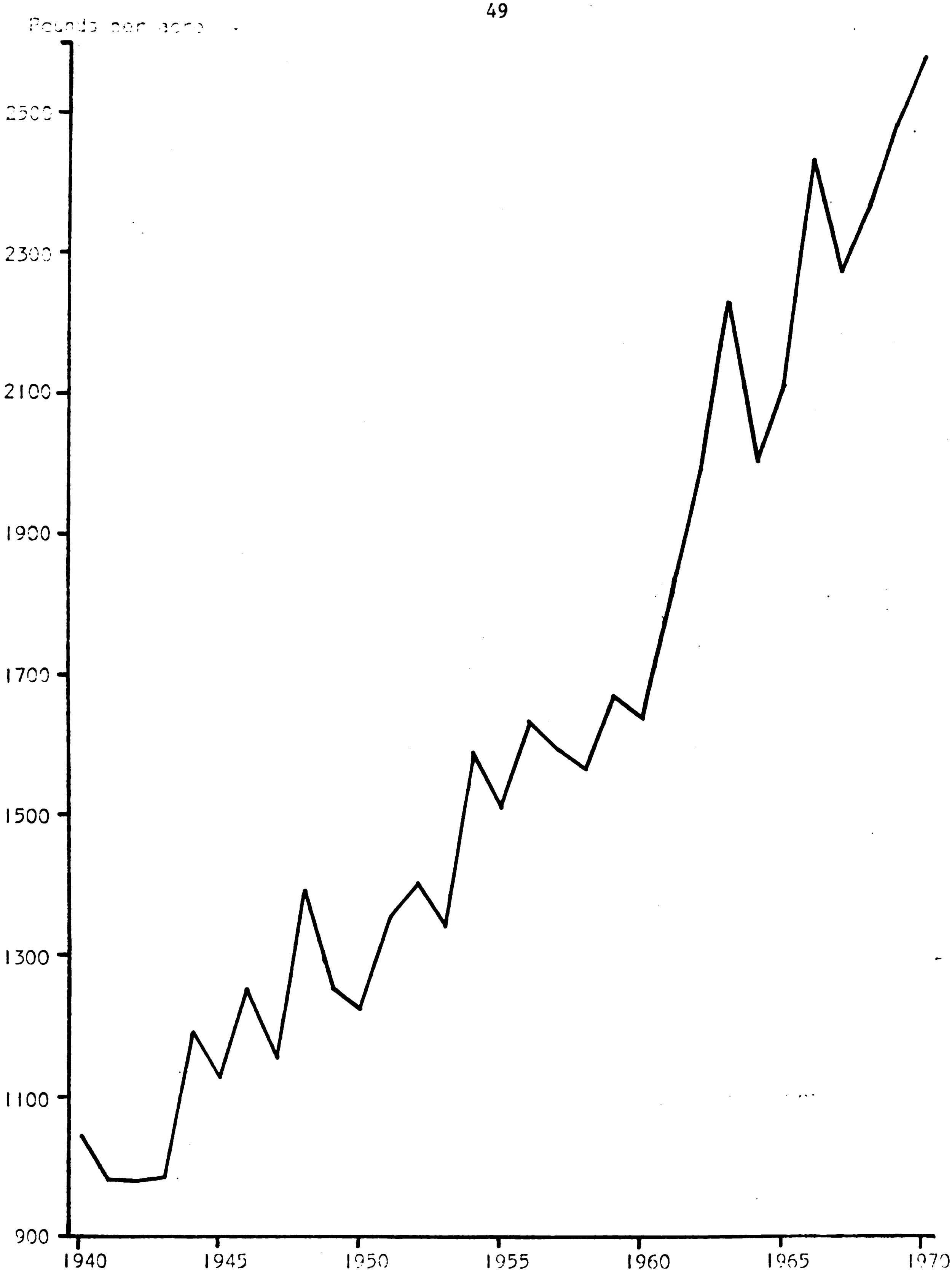
This is taken to explain the negative forecast error in 1955, and why it was smaller than experience in the previous 10 years would suggest it should be.

As noted above, in 1961 a new trend appears in yields as can be seen in Figure 2.23. From an annual trend of 39.3 pounds per acre increase in yield for the 1935-1949 period, this increased by 187 per cent to a trend of 73.5 pounds per acre in the period 1961-1970. This appears to be the result of a number of institutional and economic factors which meant that, given the high profitability of burley production,[41] and with the decrease in allotted acreage, the only way for

---

[40]See Pub. L. 276, 78th Cong. 58 Stat. 136, (March 31, 1944), amended by Pub. L. 528, 82nd Cong. 66 Stat. 597, (July 31, 1952) amended further by Pub. L. 21, 84th Cong. 69 Stat. 24, approved March 31, 1955. Prior to 1952 allotments of 1 acre or less had been protected from further reduction, in 1952, allotments of 7/10th acre could not be reduced by more than 1/10th acre in any year. The 1956 amendment allowed acreages down to 1/2 acre to be reduced by no more than 1/10th acre in any year. See USDA, Compilation of Statistics, op. cit., 1955, p. 31; 1961, p. 37; and 1969, p. 48. Also Johnson, Burley Tobacco, op. cit., pp. 99-101.

[41]Tobacco production, of which 85-70 per cent is burley in Kentucky, uses 2 per cent of the total cropland of that State, 25 per cent of productive farm labor and accounts for 35-50 per cent of total agricultural income in Kentucky. See Ira E. Mossie, George A. Everette and J. H. Smiley, Burley Tobacco Production, Kentucky cooperative Extension Service Circular 616, (Lexington: University of Kentucky, 1968), p. 1.



Source: see Table 2.21

FIGURE 2.23 -- Average yield per acre for burley tobacco, United States, 1940-1970.

a farmer to increase or maintain his income from this source was to increase yield. The sum effect seems to be an increased use of old and new technologies. To mention a few, there was the advent of the use of clear plastic for covering seed-beds, the development of higher yield, disease resistant varieties and also, in 1959, burley hybrids were released for the first time. There was also a considerable increase in the knowledge of chemical factors involved in the production of high yields of good quality burley which gave rise to improved management techniques. This included the correct use of greater quantities of fertilizer including nitrogen.[42]

In fact, substance is given to this speculation when a new value for trend is computed based on the figures obtained by adding the forecast error to the estimated value for trend calculated from the original parameter for this variable. This trend for the adjusted data for 1961-1970 was 112.98 compared to 59.62, originally estimated[43] or a 189 per cent increase. In other words, most of the change in the raw data would appear to be explained by an increase in trend. As

---

[42] George B. Lucas, Diseases of Tobacco, (Second Edition, New York and London: The Scarecrow Press, Inc., 1965), p. 32 described the increased use of plastic cover for seed-beds with the decrease in price of this product as having the advantages of 1) delaying seeding 2-4 weeks which gives a reduction in management time and risk of injury due to cold; 2) enables less seed to be used; 3) more, and stronger, more even seedlings; 4) allows less fertilizer and fungicides to be used, also better control of moisture and temperature. For the development of new varieties see Ibid., Chapter 3. The effect of smaller acreage would allow greater use of longer rotations and have better disease control. See also B. C. Abehurst, Tobacco, (London and Harlow: Longmans, Green and Co. Ltd., 1968), pp. 66-70 for discussion on the development in the methods of soil sterilization available. For a description of changes occurring in management see especially, Ibid., Chapter 9 and also, Ira E. Massie, et al., op. cit.

[43] See above, p. 36.

possible additional evidence, the size of the residuals and forecast errors appear to be very similar when the trend effect is allowed for from 1961-1970.[44]

Because of the relative stability and controlled nature of the industry in later years, no problem seems to have been caused by the high multicollinearity originally identified as being a possible problem with the price, cost index, and trend variables. Since 1962, the inflation of costs of production items appears to have been equally affected by an increase in burley prices; thus, the overestimation of one effect was offset by the opposite overestimation of the effect of the other.

Finally it would seem that any forecaster with a knowledge of this section of the burley industry would have been aware of the influence of the various factors mentioned above in the years they occurred. Of the factors explicitly stated as being a problem only one, the effect of changes in the number and size of allotments, was involved regularly after 1950. The values for this factor are available no later than February 1 after 1956 and by December 1 of the year before, prior to 1956. Further, the change in trend that appears to have taken place in 1961 should have been indicated at least by 1962 since the forecast error in that year was nearly twice as large as any previous error. Undoubtedly there would have been problems in

---

[44]The standard errors are 49.2 for the 1935-1949 period; 44.2, 1950-1960; and 309.9, 1961-1970 before allowing for the new trend, and 54.5 when it is allowed for. This becomes even more significant when adjusted for the average size of yield in these periods, since with high yields, greater absolute variability would be expected. The standard errors when expressed as a percentage of the average yield for the periods become 4.75, 2.94, and 2.44 per cent respectively. This also substantiates the hypothesized greater stability in the industry caused by the control program.

measuring the importance of the new trend because of the number and complexity of the factors which it covers.

Summary

This analysis has provided reasonable grounds for the belief that not only are the forecasts verifiable, though their usefulness might have been improved by redefinition of the variable representing production costs, but that the forecast procedure is also verifiable. Further, the procedure was shown to have structural validity. Not only did it continue to give predictions within the same error bounds as for the period in which it was estimated, but it also proved useful in indicating the effect of other factors, especially the size and distribution of allotments, which were not incorporated in the model. It also showed up the structural change that appears to have occurred in trend. Confirmation of the speculated reasons for the departures given above requires, at least the refitting of the model, which is beyond the intention of this study.

The multicollinearity that exists between three of the explanatory variables did not appear to cause trouble, probably because two of them, the price of burley, and index of prices paid continued to move together, thus offsetting the effect of each other.

The two main factors of concern then appear to be, firstly, that the structural effects of changes in acres planted in burley are more complex than can be captured by the single variable, acreage allotments less normal acreage, specified in the model. Possibly the inclusion of an additional variable, changes in numbers of allotments from normal, might have helped explain the behavior of this section in determining yield. Secondly there was the marked change in the type and rate of adoption of technology occurring in about 1961.

Finally, it would appear that, especially with the inclusion of the above factors, this model might be worthy of further analysis to determine the accuracy of its forecasts.

3. The Auction Model[45]

The Model

This model consists of two structural equations which, because of the joint, interdependent relationships between the price of burley, and the amount of burley going under nonrecourse association loans and five other exogenous explanatory variables, were estimated as a simultaneous equation system in their reduced form and then converted to their structural form. This ensures that the disturbance term is apportioned among the variables without bias.

The reduced form equations were fitted individually by ordinary least squares procedures to data for the years 1935-41 and 1945-49. This gave 12 observations and 6 degrees of freedom with which to estimate the variances for each equation.

The equations for the model in their structural form were:

$$Y_1 = \underset{(.16)}{.246Y_2} - \underset{(.08)}{.145X_2} - \underset{(.29)}{.037X_3} - \underset{(.05)}{.061X_4} + \underset{(.14)}{.280X_5} + \underset{(48)}{26.44}$$

$$Y_2 = \underset{(2.47)}{3.101X_1} + \underset{(.33)}{.458X_2} + \underset{(1.43)}{.175X_3} + \underset{(.20)}{.151X_4} - \underset{(.68)}{.771X_5} - \underset{(185)}{70.64}$$

Y_1 = U.S. season average price (in cents per pound) received by farmers at the auction (endogenous)

---

[45] Ibid., pp. 56-71 and Appendix B pp. 109-111.

Y_2 = Pledges of burley tobacco to associations for non-recourse, price-supporting loans (endogenous) (measured in millions of pounds)

X_1 = Support price level (cents per pound)

X_2 = U.S. production of burley in pounds (exogenous) (millions of pounds)

X_3 = Index of quality of current year's burley crop (exogenous) (per cent)

X_4 = Stocks of "old crop" burley on hand in U.S. October 1 preceding the opening of the auction (exogenous) (millions of pounds)

X_5 = Disappearance (U.S. consumption plus exports from U.S.) for year ending October 1 preceding opening of auctions. This variable is interpreted as increasing trend in demand, changes in income, and industrial activity (exogenous) (millions of pounds)

The main misspecification, which did appear to bias the estimates of the dependent variables, was that the relationship between pledges and support price less the estimated "free-market" price was curvilinear rather than linear.[46] This was a consequence of inadequate knowledge of appropriate econometric techniques at the time the model was fitted.

In addition, the quality index used did not appear to perform correctly as its parameter was insignificant and of incorrect sign. Because of the nature of the tobacco industry at the manufacturing level, the explanatory variable, disappearance, X_5, measures shifts in anticipated demand for cigarettes two or three years after the date of

---

[46] Johnson, <u>Burley Tobacco</u>, <u>op. cit.</u>, see graph and discussion p. 66. Note: the estimated "free-market" price, Y_F, is:
$Y_F = .246(Y_2 = 0) - .145X_2 - .037X_3 - .061X_4 + .280X_5 + 26.44$
i.e. the price that would occur in the absence of a support program.

leaf purchase. This meant that in some years the preceding year's disappearance does not reflect current psychological tendencies among buyers making, X_5, a poor measure of anticipated demand.

The Data

Apart from the quantity index, all data for this model were available in various official sources for the years 1950-1970 used for testing the model (see Table 2.31). In the case of the quality index, it did not prove to be feasible to estimate an index on the basis used by Johnson. This method was to build up a ranking from 1 to 5 for the index "for earlier years based on interviews with informed tobacco warehousers and dealers. In later years they were supplemented with my own observations and some market data then available."[47] Instead, an index of quality was constructed from the ratio of the quantity of "lugs" to quantity of "leaf" in each year's crop, for the years 1945 to 1970. "Lugs" form one grade of tobacco which, especially prior to new processes for shredding "stems" and blending "scrap" which were introduced into the trade in the mid 1950's along with general blending processes, commanded a premium for cigarette tobacco. "Leaf" forms the bulk of the tobacco sold. Thus, generally, the higher the proportion of lugs to leaf the higher will be the quality of tobacco offered in a given year.

The index was then "spliced" with that used by Johnson using the years 1945 to 1949. For these years, except for 1945 when it appeared that the new index should have not been so low, it corresponded very

---

[47]From personal correspondence with Dr. Dana G. Card, Professor Emeritus of Agricultural Economics, Kentucky University, Lexington, dated July 1, 1971.

TABLE 2.31.--BURLEY TOBACCO, AUCTION MODEL: DATA USED, PREDICTIONS OBSERVED, UNITED STATES, 1935-1970.

Year	Average Price of Burley Tobacco (cents per lb)		Pledges for Non-recourse Loans (Millions of lbs)		U.S. Production of Burley Tobacco[e] (Millions lbs)	Quality Index (1939-48=100)		Stocks of Burley Tobacco October 1[h] (Millions lbs)	Disappearance of Burley Tobacco[i] (Millions lbs)
	Actual[a]	Predicted[b]	Actual[c]	Predicted[d]		Original[f]	Present[g]		
1935	19.1		0		222.1	107		769.9	302.6
1936	35.7		0		220.4	118		681.7	309.1
1937	20.1		0		402.2	89		571.8	329.5
1938	19.0		0		339.2	107		660.7	313.5
1939	17.3		0		395.3	105		684.1	316.0
1940	16.2		26.2		376.6	82		762.3	317.2
1941	29.2		5.9		336.8	86		798.1	339.5
1942	41.8		1.0		343.5	107		755.3	379.6
1943	45.6		1.0		392.1	115		686.0	412.8
1944	44.0		0		590.6	104	110	651.2	426.9
1945	39.4		24.1		577.2	97	73	759.0	482.8
1946	39.7		147.8		614.0	86	90	853.0	482.9
1947	48.5		37.7		484.7	116	130	940.8	526.5
1948	46.0		96.7		602.9	102	102	902.3	523.2
1949	45.2		39.1		560.5	96	97	974.3	530.9
1950	49.0	48.9	44.2	61.0	499.0		129	1000.2	534.6
1951	51.2	42.3	97.3	133.1	618.1		99	981.3	518.0
1952	50.3	41.0	103.9	138.4	650.1		71	1061.2	538.1
1953	52.5	48.1	102.1	104.8	564.4		109	1163.4	547.9
1954	49.8	55.8	221.4	168.4	667.6		96	1198.2	529.6
1955	58.6	35.0	73.1	112.2	470.0		121	1346.7	519.1
1956	63.6	16.6	6.0	124.5	506.4		98	1298.8	517.9
1957	60.3	21.2	16.6	127.0	488.1		68	1294.7	510.5
1958	66.1	22.0	11.2	133.8	465.5		97	1276.5	506.3
1959	60.6	25.2	13.2	131.8	502.3		53	1224.3	517.8
1960	64.3	33.2	8.4	106.2	484.7		58	1191.4	535.1
1961	66.5	27.8	10.3	128.9	580.3		53	1127.3	548.8
1962	58.6	33.3	63.5	155.4	674.9		33	1137.4	570.3

1963	59.2	53.7	202.3	199.1	755.1	47	1227.9	584.4
1964	60.3	35.8	110.4	176.5	619.8	43	1412.2	570.9
1965	67.0	36.0	42.2	130.5	586.3	54	1415.7	616.3
1966	66.9	39.9	62.5	137.3	586.7	52	1395.3	607.7
1967	71.8	45.1	64.2	126.7	540.6	71	1381.5	600.5
1968	73.7	41.9	56.2	139.5	563.4	97	1324.1	599.0
1969	69.6	57.3	158.9	172.2	591.4	54	1316.0	571.0
1970	72.2	31.1	47.7	175.2	561.0	47	1343.0	564.0

[a]Col. 1. U.S. season average price of burley tobacco: USDA, Agricultural Outlook Charts, 1951, and 1971.

[b]Col. 2. Predicted price of burley tobacco: computed from equation p.

[c]Col. 3. Pledges to the associations for price supporting nonrecourse loans: USDA, ASCS (formerly CSS), Fiscal Division, Financial Analysis Branch, Commodity Credit Corporation Charts, (Washington, D.C., various issues).

[d]Col. 4. Predicted pledges: computed from equation p.

[e]Col. 5. U.S. production of burley tobacco: USDA, Agricultural Statistics, (Washington, D.C.: U.S. Government Printing Office, various issues).

[f]Col. 6. Index of quality of burley tobacco: 1935-49 from worksheets, Johnson, op. cit., 1950-70 see pp. 20 and 22 above, data from USDA, CMS, Tobacco Division, Tobacco Market Review (Light Air-Cured), Pt. 1, Type 31, Burley, (Washington, D.C.: various issues).

[g]Col. 7. Stocks of burley tobacco October 1 before the opening of auctions: USDA, Agric. Stat., op. cit.

[h]Col. 8. Disappearance of burley tobacco: ibid.

closely to the "old" index values. For the years 1950 to 1970 (see Table 2.31) the values appeared to perform very well when compared with comments for the various seasons' crops given in 'Season' Tobacco Market News Reports and Tobacco Market Review published by the USDA except for the value in 1950 which should have been higher. It is also possible that the values for 1953, 1955 and 1967 should have been a "little" higher.

Testing the Model

In this section the underplantings model will be evaluated according to the procedure outlined in Chapter I. Since the procedure has already been demonstrated in detail for the previous two models, the presentation for this model will be abbreviated where appropriate.[48]

Verifiable Predictions.--As before, this is a preliminary check to see whether the conditions for verifiable predictions are, or might be met.

Following the reasoning used previously, condition one is met, as is condition two. Once again, condition three, with regard to when the forecast for a given year would be made, is unclear. Apart from the usefulness of knowing what caused the forecasted values of the dependent variables, it would also be desirable that the forecasts be available either before the event, or merely before other estimates of similar accuracy are known. An examination of USDA statistics show that preliminary figures for the annual price and

---

[48] See above Chapter I, p. 15 ff. especially p. 17, Chapter II, p. 25 ff. for the underplantings model, and p. 42 ff. for the yield model.

pledges of burley tobacco were first available at the end of December, during the late November to January or February auction period. They both were invariably accurate to within 1 per cent in the period sampled, by the end of March.[49] Thus it would be desirable for the model to make forecasts of these variables before this time.

From an examination of when reliable data might be available for the explanatory variables, it seems that, with some reservation, forecasts could be made at the beginning of October prior to the opening of the auctions.[50] The accuracy of these forecasts remains to be determined. This will not be attempted in this thesis.

The fourth condition will be met, for the period in which the model is estimated at any rate, if the estimate of the variance

---

[49] Prior to 1955 the preliminary estimates were not given until February. For the entire period, the final USDA estimates for price were available by the June following the auctions. Most often, this figure was available by the end of March. The final estimate for pledges was always given by August or early September, though it too, was often available by the end of March.

[50] The final support price is known at the beginning of October. Stocks and disappearance, although not final until December, were invariably within 1 per cent of the final USDA estimate at this time. There is a problem with the availability of data for the production variable and the quality index. If the yield and underplantings models gave sufficiently accurate estimates of production at this time, (which is not determined in this thesis) there would be no problem with respect to the variable. USDA estimates, however, show considerable variability from year to year. In some years estimates are within 1 per cent by October prior to the opening of the auction, and in others not until the following March or June. For the quality index, final estimates would not be available until May following the auctions, on the basis it was computed for testing the auction model. However, if the model were being used, it seems it could be calculated by October, if this was done in the same manner as for the original index used, or possibly by some sampling procedure to obtain estimates of the quantities of leaf and lugs used for computing the present index. In either case, however, this variable as estimated for the model does not significantly influence forecasts.

made then was valid. However, the author pointed to reasons which would make this questionable. This means that the usefulness of confidence intervals for forecasts based upon this variance is also questionable.

One problem was that interdependencies were hypothesized to exist between some of the variables.[51] In order to retain some desirable statistical properties for the estimators of the population parameters, they were estimated in their reduced form as a system of two simultaneous equations. Estimated in this manner, however, the only statistical properties which can be obtained for the estimators depend upon large samples being used.[52] There is some question as to whether, in this case, 12 observations with 6 degrees of freedom[53] could be considered large for this purpose.

A more serious problem, though, from this point of view, is the unavoidable misspecification of the relationship between pledges and the support price less "free market" price.[54] Because of this misspecification, none of the desirable statistical properties can be obtained. However, for practical purposes, all is not lost, since the size and nature of the biases that are likely to result were determined by the author.

---

[51] See above, p. 53.

[52] For example the properties of consistency and asymptotic efficiency.

[53] The question on what number of degrees of freedom in fact exist with which to make an unbiased estimate of the population variance, σ^2, has not been definitely determined by econometricians, although it is generally held that in a case such as this, 6 would be the maximum.

[54] See above p. 54.

In summary, the predictions from the auction model do appear to be verifiable initially, but with restrictions regarding the time when forecasts might be made, and the validity of the confidence intervals for forecasts.

Verifiable Forecast Procedure.--For the period in which the model was fitted, this condition appears to be met. This will now be subjected to a more rigorous test, paying particular attention to the structural relationships specified in the model.

An examination of the forecast errors for the period 1950-1970 and a comparison of these with the residuals for the years 1935-1941 and 1945-1949 will give an indication of the performance of the equations (see Figure 2.31 and 2.32).[55]

From a cursory inspection it would appear that the price equation performed satisfactorily until 1954, after which prices were consistently underestimated in each year from 1955-70, as seen in Figure 2.33. The forecast errors in 1951 and 1952 would appear to be explained by an unusually buoyant market for burley causing higher than expected prices inspite of production in each year being successively the highest recorded and the ratio of supply to disappearance, in a similar manner, being the highest since before World War II. The pattern of the forecast errors from 1955-70 suggests the existence of some sort of autoregressive disturbance entering the systems and/or the existence of some sort of curvilinear relationship

[55]Forecast errors were calculated using the price equation shown p. 53 and the data in Table 2.31 using actual values of pledges in each year and subtracting this estimated price of burley from the actual price of burley.

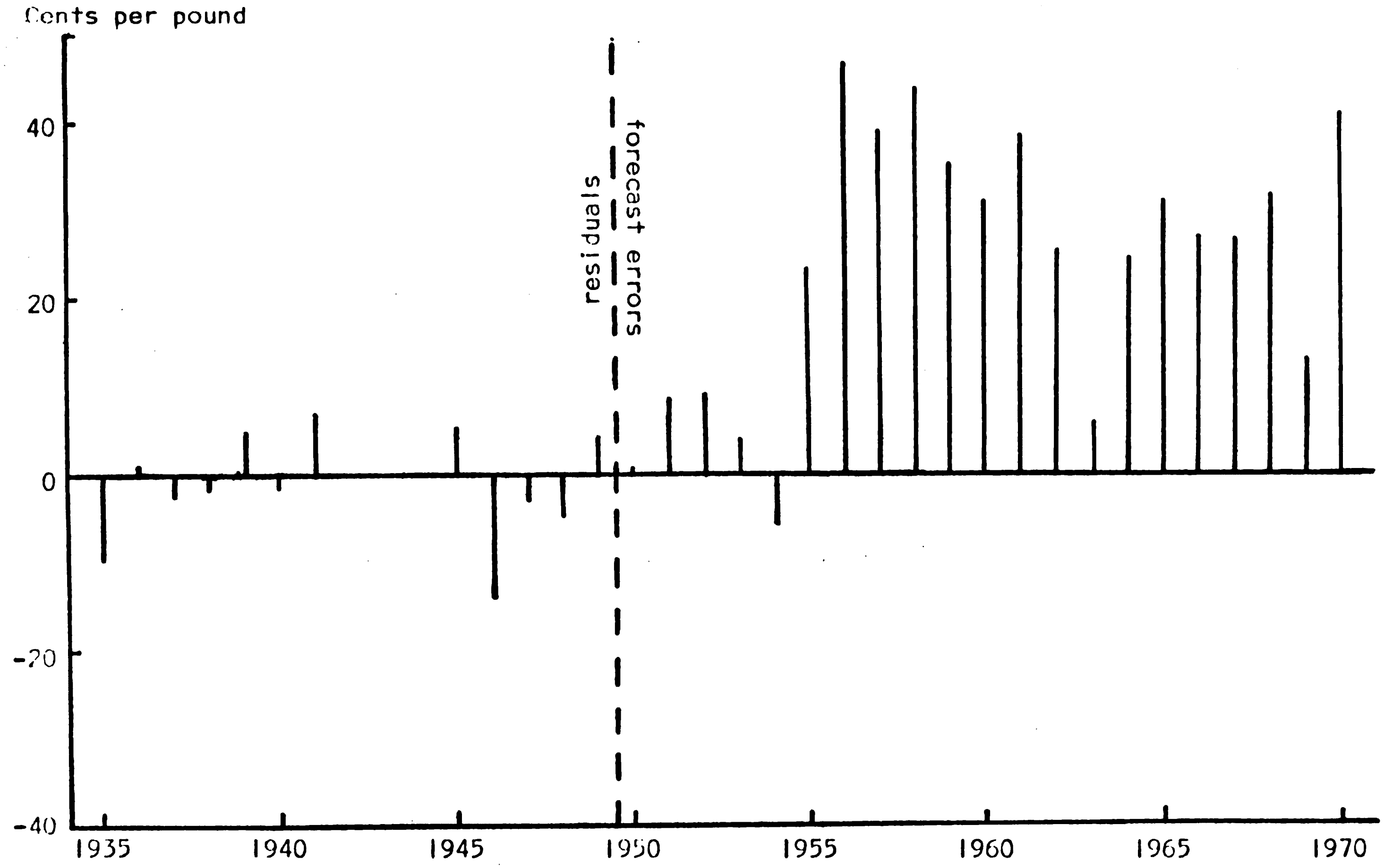


FIGURE 2.31 -- Burley tobacco, auction model: residuals 1935-1941 and 1945-1949 and forecast errors 1950-1970 for burley prices.

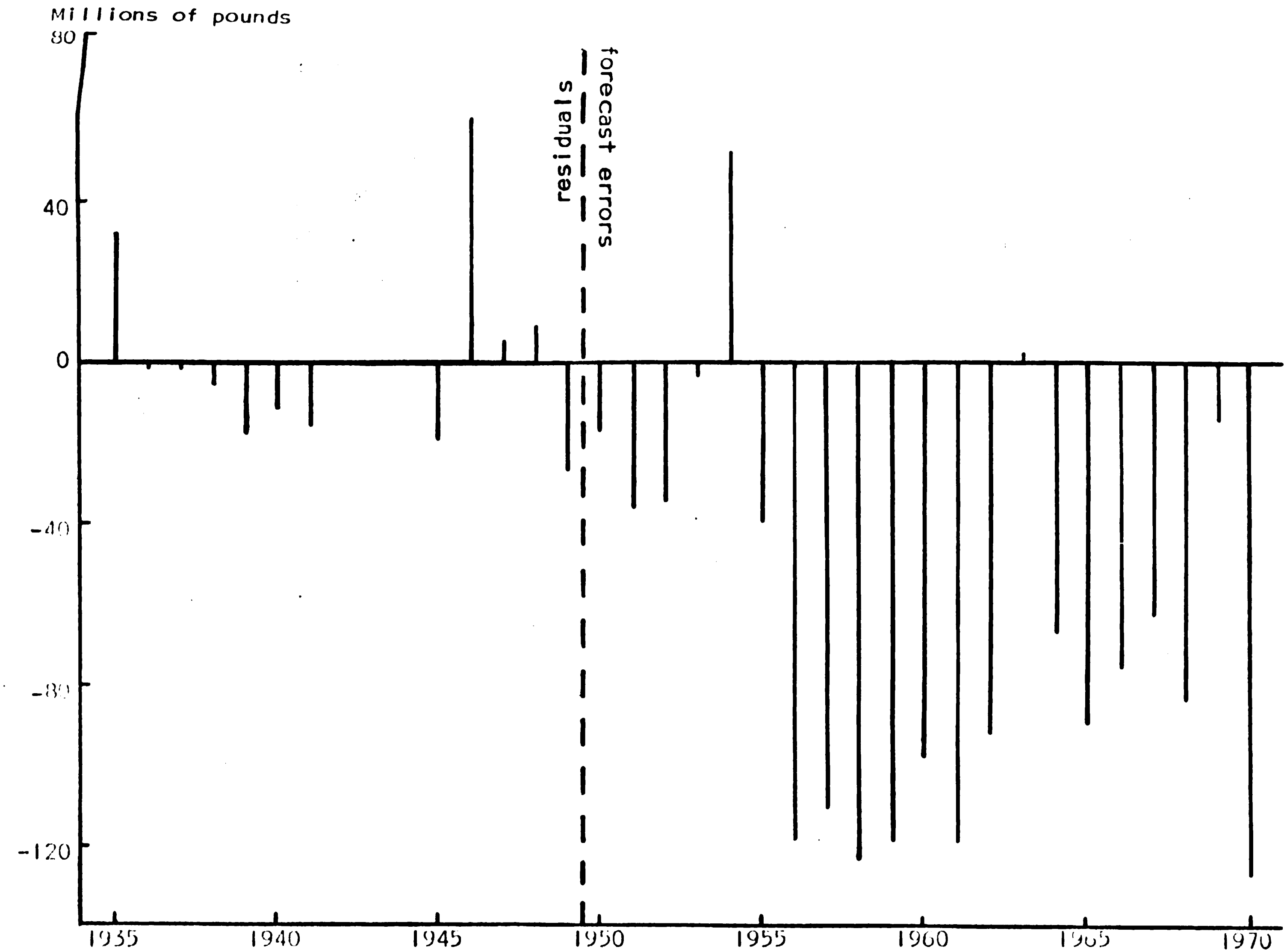
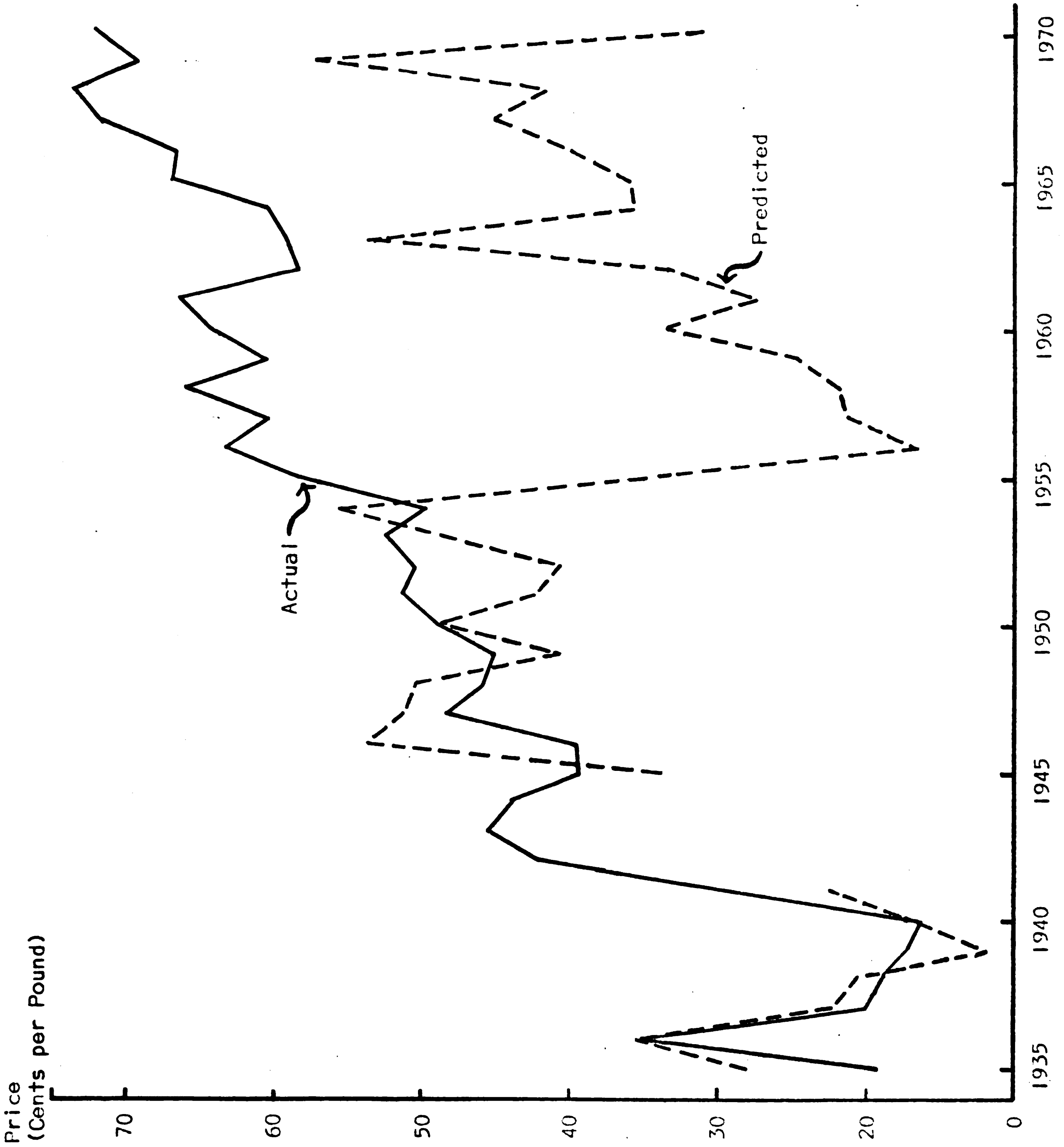


FIGURE 2.32 -- Burley tobacco, auction model: residuals 1935-1941 and 1945-1949, and forecast errors 1950-1970 for pledges for non-recourse loans.



Source: see Table 2.11

FIGURE 2.33 -- U.S. season average price for burley tobacco: actual, and predicted 1935-41 and 1945-70.

between the dependent variable and one or some of the explanatory variables,[56] or possibly misspecification of the model.

For the pledges equation, a satisfactory performance seems to be indicated for a period of six years, 1950-55, after those used for fitting the equation. This appears especially so when an allowance is made as suggested[57] for the curvilinear relationship hypothesized between pledges and support price less estimated "free market" price. The years 1950, 51, 52 and 55 could all be categorized as years of "strong" prices for burley and the magnitude of the forecast errors are also in correspondence with the relative strengths of those prices, so that when this allowance is made, the size of these errors would be even smaller. 1954 was a year of very weak burley prices due to the highest production up until that time, the highest ever ratio of supply to disappearance, and the very poor quality of the crop. The relationship specified indicates that an allowance in this case should be made by increasing the size of the pledge predicted by the equation. This would reduce the size of this error.

In 13 out of the 15 years 1956-70, the forecast errors are large and negative. This indicates the equation was consistently overestimating pledges. The small errors in 1963 and 1969 and indeed even the small residual in 1953 appear to be largely "accidental." The reason for this conclusion is that values of the explanatory

---

[56] See Kmenta, op. cit., "Tests for Linearity," pp. 466-472, especially pp. 470-472, for a discussion of the possible tests of linearity and their inability to distinguish between autoregression and non-linearity in time-series data where the ordering of the residuals according to the size of the explanatory variable is similar to their ordering over time.

[57] Johnson, op. cit., p. 71.

variables in these years were such that they lay close to the fitted linear relationship between pledges and support price less "free-market" price, while they appeared to bear no relationship to the "true" curvilinear relationship hypothesized by Johnson.

As for the price equation, the forecast errors for the years 1955-70 in the pledges equation suggest an autoregressive disturbance and/or a curvilinear relationship existing somewhere in the model rather than a linear one that had been assumed. It can be seen from comparing the errors for the two equations in three years in Figures 2.31 and 2.32, one is roughly the mirror-image of the other.

To explain successfully the reasons for the break down of the model would require at least a careful reexamination of the hypothesized behavioral relationships underlying the model, respecifying them where necessary, and evaluating the fit of new equations. To attempt to specify the sources of the break down without refitting is difficult because of the number of relationships possible from the number of variables and the simultaneous relationships existing between the dependent variables. The unavoidable misspecification already referred to above also complicates any such attempt, since it reduces the dependence that can be placed upon the forecast errors to illustrate changes in behavior.

However, three reasons will be considered as to why the breakdown occurred. Two of these will be based upon historical evidence which suggests a change in the behavioral relationships underlying the model, and the third involves possible mistakes in the estimation of the model parameters. The "truth" may involve one, all, or any combination of these three possibilities.

A. Changes in Behavioral Relationships.--What evidence is there of changes in the behavioral relationship occurring after the period in which the model was fitted? To begin with, the appearance of high positive errors for predictions of prices of burley from 1955-70 and high negative errors for pledge forecasts are consistent, since an underestimation of price would be compensated by an overestimation of pledges or vice versa. Historically, record high production in 1954 following on generally high levels of production since the war had built up an all-time high ratio of supply to disappearance as can be seen in Table 2.31. This severely weakened the market when considered along with the technological advances in the tobacco trade which enabled a greater proportion of a tobacco leaf to be utilized, and the introduction of filter-tip cigarettes, which meant that less tobacco was used per cigarette.[58]

These factors in turn meant that the government had amassed considerable stocks of tobacco prior to 1954 and with one-third of that year's record crop being placed under loan to support the market price, overall government stocks were considered to be at an unacceptably high level. All this in spite of an 8 per cent cut in most farmer's allotments for that year. A serious reassessment of the situation was called for by all sectors of the industry.[59]

Initially a 10 per cent reduction of allotments was announced. But by this time approximately 64 per cent of allotments were down to

---

[58]This latter effect was largely cancelled however by the introduction and increasing popularity of king-size cigarettes.

[59]USDA, "Tobacco Leaf Situation and Outlook--Burley," Tobacco Situation, (Various issues of 1954 and 1955, especially March 1955).

seven-tenths of one acre or less, which by P.L. 528 enacted in 1952, meant they were protected from further reduction in acreage[60] meaning that further cuts of total allotments were heavily biased against the larger producers of burley. New legislation was proposed in March 1955 to reduce the size of acreage allotments protected against further cuts from seven-tenths of an acre to one-half an acre. This was upheld by 96 per cent of burley growers in a referendum where they also agreed to a further 15 per cent cut in the burley allotments to apply for 1955.[61]

The question that would be now posed is, what if any effects had these and other developments on the behavior of the tobacco manufacturing industry (the buyers of farmers' tobacco) bearing in mind that it is an industry dominated by a few large firms? This latter factor leads for instance to the possibility of the decision processes of one or two firms profoundly influencing the whole market process or even some degree of collusion between these firms, albeit without direct negotiation.

In this vein, it might be hypothesized that by the mid-fifties anyway, these firms would have been convinced that the government could accumulate and then dispose of considerable quantities of burley tobacco under the support program without causing any noticeable decrease in the average season price for burley by cutting future production and/or exploiting its monopsonistic powers. Now burley after it is purchased at the auctions is processed, cured, and traded for a period varying

---

[60] Ibid., February 1953.

[61] Ibid., June 1955.

in length from two to five or more years. This allows tobacco to be accumulated by manufacturers in their correct proportions with respect to both types and grades within types for manufacture into the finished cigarette. Once it became obvious then, that the government support program was not buying tobacco at higher supported prices and then selling in good years, but deflating market prices in the process, it is postulated that manufacturers preferred to purchase directly the types and grades they required as they became first available at auction, even if it meant paying slightly higher prices than would otherwise appear to be necessary considering the amount being currently produced.

a. One behavioral pattern that would seem to be consistent with this postulate, is that manufacturers may have begun to weigh their decisions on the amount to purchase and prices to pay for burley in more recent times, less on relationships connected with support price and more on the size of a year's crop given the stability the government program imposes on the industry. It is possible that some strength is given to this point, when the forecast errors for the years 1951 (not 1954) to 1970 are arranged in order of increasing production. When arranged in this manner, there is a stronger suggestion, on a probability basis, of the existence of a curvilinear relationship than when the residuals are ordered in strict chronological sequence.[62] The relationship indicated is that, as the size of the crop increases in any year, the manufacturing industry at first tends to purchase the crop at prices that become higher, but at a decreasing

---

[62]Note footnote 56, p. 65.

rate, than those that would be predicted. Once the crop reaches about 500 million pounds, however, actual prices paid begin to gradually converge with those that would be predicted until they equal predicted prices at a level of production of between 670 and 750 million pounds. Similarly, in the case of pledges, they become at first increasingly less than predicted by the original relationships, but at a decreasing rate, and then gradually increase until they are approximately the same as predicted pledges at high levels of production. This might be tested by incorporating an additional variable raised to the second power for production, in the model.

b. Alternately, there is evidence that the original curvilinear relationship between pledges and support price less "free-market" price merely underwent a transition from 1951-1954 as the manufacturers preferred, given the government behavior, to purchase larger crops and own larger stocks than they would have been prepared to earlier, at a given market price. This would give rise to a larger differential between support price and "free-market" price.

This fits in with the large differential, seen in Figure 2.34, appearing in 1951 between the two variables. There would have been shift of the relationship in each of the years 1951-1955 after which it would have stabilized somewhat to the new curvilinear relationship. This was suggested by an examination of the relationship of the residuals and forecast errors to the linear relationship between pledges and support price less "free-market" price that was used in the model.[63] However, it appears that even using the shift to the

---

[63] This would be a diagram similar to that used by Johnson, Burley Tobacco, op. cit., p.66, Figure 18.

new curvilinear relationship there would have been large errors in some years. In fact there appears to be some evidence that there is a factor(s) which regularly shifts this relationship if the relationship is indeed correct.

Which, if either, of these possibilities is correct, cannot be determined on a priori grounds or by the qualitative nature of this analysis, as was warned above. It may even be that both apply.

B. Effects of Inadequate Data on the Estimates of the Model's Parameters.--Another possibility exists. That is that the true relationships were incorrectly estimated and/or specified in the model. Evidence for this suspicion would be the fact that the "free-market" price was never above support price in any year after those used to fit the model, i.e. 1949, as can be seen in Figure 2.34. For the period in which the model was estimated, "free-market" price exceeded the support price in 7 of the 12 years, and 5 of these, from 1935-1939, were caused by their being set arbitrarily 8 cents below actual prices. This was before the control program began and was to ensure that no takeover occurred in those years. In addition, from 1939-1947 the support price was caused to inflate at an artificially high rate because it was set 8 cents below the actual price (which was also the "free-market" price in that year), in 1939.

Thus, with such a high proportion of artificially created "relationships" in the sample, which in total contained only 12 observations, it appears quite possible that the estimators of some of the true parameters may be incorrect.

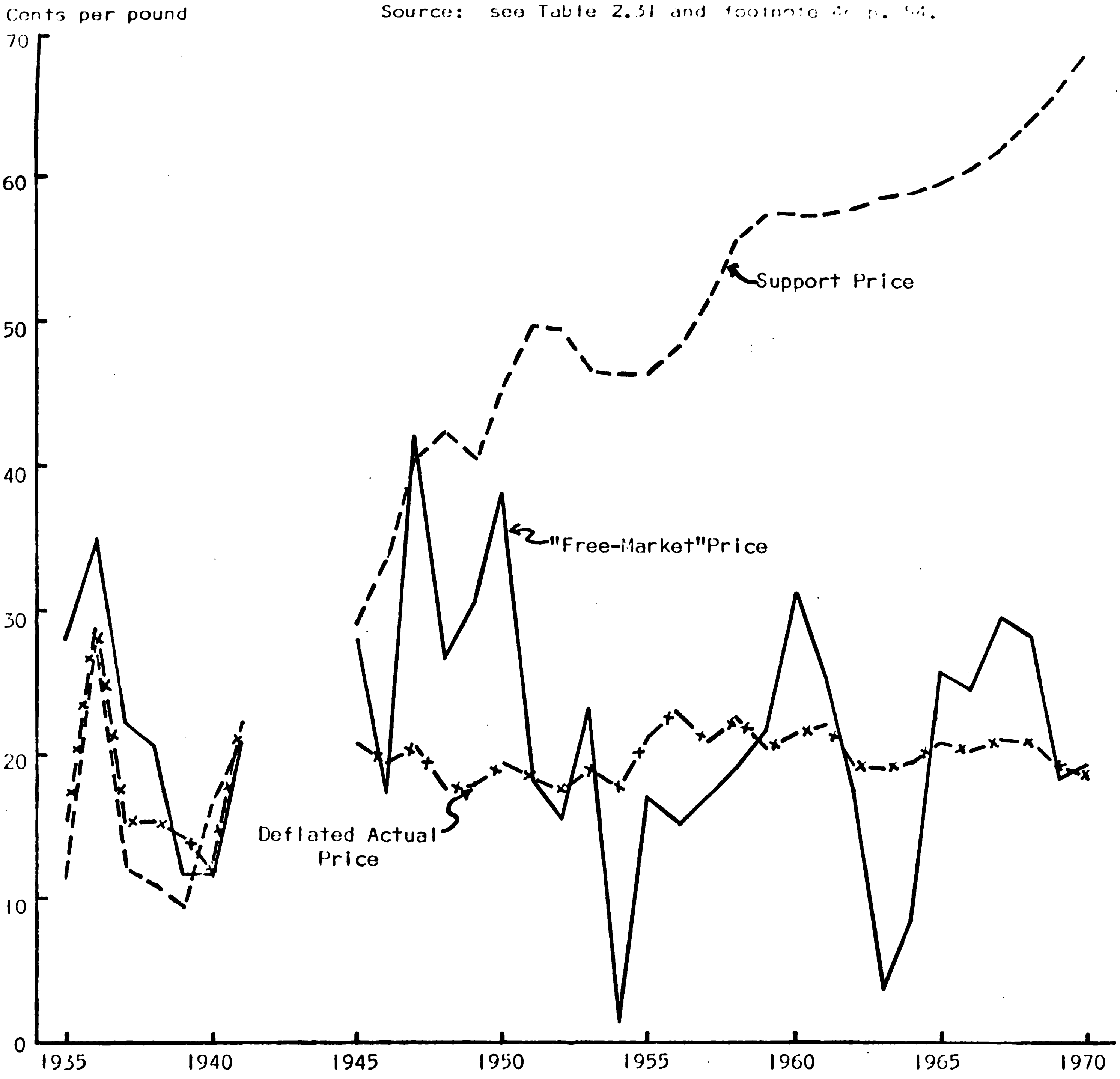


FIGURE 2.34 -- Support price, estimated "free market" price, and deflated actual for burley tobacco, United States 1935-1941 and 1945-1970.

There is evidence, however, to suggest that this affects only the parameters of the support price and pledges in the structural equation and the variance estimate.[64] The remaining parameters are correctly estimated and their variables structurally correct. These are the variables which determine "free-market" price.[65]

As Johnson explains, out of the values and beliefs involved in the development of the support program for burley, two principles emerged.[66] These were that price stability was needed in the industry, and that the benefit from increases in efficiency of production from technological advance and price stability should be retained for the producers rather than handed on to the consumer, but that burley should not be favored relative to other agricultural crops. This meant that the real price of burley should be maintained.

It would be suspected that as experience was gained in administering the program, these objectives would have been met. That this was achieved as expected is supported by the behavior of the estimated "free-market" price[67] in relation to the actual price of burley deflated by the farmers' parity index, as can be seen in Figure 2.34 and also from the statistics in Table 2.32.

---

[64] See above, p. 53 for the structural equation, and also Johnson, Burley Tobacco, op. cit., pp. 109-110 to trace the effect of the estimates of the reduced form parameters being converted to the estimates for the structural parameters.

[65] See p. 54 footnote 46.

[66] Ibid., p. 80 ff.

[67] See above, p. 54, footnote 46 for its derivation.

TABLE 2.32.--SOME STATISTICAL INDICES FOR "FREE-MARKET" PRICE AND DEFLATED ACTUAL PRICE OF BURLEY IN THE UNITED STATES FOR TWO PERIODS, 1935-49 and 1950-70

	1934-49	1950-70
"Free-Market" Price of Burley[a]		
Mean Value, M	25.5736	19.9222[c]
Standard Error, S_1	9.3691	8.6658
$\frac{S}{M}$	.3664[c]	.4350[c]
Deflated Actual Price of Burley[b]		
Mean Value, M	19.8733[c]	20.0143[c]
Standard Error, S_1	5.0594	1.5418
$\frac{S}{M}$	.2546	.0770

[a]See above p. 54, footnote 46 for its derivation (cents per pound).

[b]The actual U.S. season average price for burley deflated by the index of prices paid by U.S. farmers (cents per pound).

[c]These values are not significantly different statistically at the .05 per cent level using a two tail test.

This shows, prior to 1951, that for the years 1947-1950, with the "free-market" price higher than the actual real price of burley, some of the benefits of the program were, or were in danger of being, passed on to the consumer. However, by adjusting allotments, the supply to disappearance ratio was adjusted to reduce this pressure and from 1951-1970 the "free-market forces" were allowed to fluctuate around the actual real price of burley.[68] That the price supports achieved greater stability can be seen from the smaller fluctuation of the actual real price compared with the "free-market" price since 1950, and also from the smaller fluctuation for the real price in this period compared with the fluctuation for the price in the previous period 1935-1950.[69]

Thus, since this analysis supports what was expected to have occurred it is argued that the forces which determine the "free-market" price were indeed correctly specified and measured in the model.

Summary

While it appeared likely that the forecasts and the procedure by which they were formed were verifiable, the analysis above did not further substantiate these claims.

Reasons for a major change in the behavior in the industry that appeared to be indicated by the forecast errors were sought. Two

---

[68]See the mean value for the "free-market" price and the deflated actual price of burley in Table 2.32, and also the values for these variables illustrated in Figure 2.35 above.

[69]In Table 2.23 the standard errors measure the variability while this value adjusted for the size of the mean value, i.e. S/M, measures stability.

which were suggested by historical records of the industry were evaluated. However, although there was evidence for both explanations on a priori grounds and from an examination of the forecast errors, no conclusion could be reached as to which, if either, was correct. This was largely because no great weight could be placed on the evidence suggested by the size and distribution of the forecast errors.

This latter deficiency was, in part, caused by a misspecification made in the model which was pointed out by its author. The deficiency was complicated by the artificial nature of some of the data used in estimating the model, which may have caused some of its parameters to be incorrect, in particular the parameters for the support price and pledges variables in the two structural equations for pledges and price respectively. It will have also biased the estimate of variance. Evidence was presented, however, which tends to verify that the variables which determine the "free-market" price are structurally valid and their parameters correctly estimated.

In conclusion the forecast procedure, i.e. the model, could not be verified, which means that its forecasts cannot be verified either. Although a portion of the model was shown to be structural, doubts as to the nature of the remaining relationships it captures greatly reduced its usefulness for suggesting when changes in behavior occurred in the industry, and what the nature of such new behavior might be.[70]

---

[70]It should also be noted that a change in the method of determining support price was instituted by new legislation (see Tobacco Situation, op. cit., February 1960 issue) to take effect in 1961 after holding the support price at its 1959 level for 1960. This change was not discussed. In addition, legislation proposed in April 1965 (see Ibid., June 1965 issue pp. 29-32) has been voted into law for burley tobacco. (April 14, 1971-PL. 92-10, see Ibid., June 1971 issue p. 14). This is a poundage control program rather than an acreage control which would require a complete re-evaluation of the models used in this study.

CHAPTER III

THE MICHIGAN DRY BEANS MODELS[1]

The Michigan dry bean models were constructed to analyse the effects of the post war price support program upon dry bean producers in Michigan. In constructing the models, an explicit objective was that they should represent the true structural relationships involved in the industry. Their ability to make predictions, while mentioned in the text on several occasions was not stressed by the author as it was for the burley models. Nevertheless, if the models for this study do accurately represent the structural relationships, they should at least provide a desirable basis for making predictions. The objective of this thesis will be, on a preliminary basis, to evaluate to what extent the models do provide such a basis.

As for the burley tobacco study, three stages were considered essential for attaining the study's objective. These were the planting stage, the growth and harvesting stage and the marketing stage. Accordingly, each was represented by an econometric model which were respectively, the acreage planted model, the yield model and the price model.

In this Chapter each model will be taken in turn and described in more detail, noting in particular any shortcomings mentioned by

---

[1]Hathaway, op. cit.

its author. The data used to test the model, and their derivation will be outlined where they are not merely a continuation of a published official series that was used in the original estimation of the parameters of the model. The model will then be evaluated in the manner described in Chapter I,[2] emphasizing the validity of the structural relationships specified in the models.

1. The Acres Planted Model[3]

The Model

The model is a linear equation with the parameters estimated by an ordinary least squares procedure from data for the years 1928-40 and 1947-53, with 1950 omitted. This gives 18 observations and 14 degrees of freedom with which to estimate variance. The equation is:

$$Y = -11.357X_1 - .0049X_2 - .0152X_3 + 398.103X_4$$

R^2 = .8378[4]

Y = Acres planted to dry in Michigan in thousands of acres.

---

[2]See above, p. 15 ff. especially p. 17.

[3]*Ibid.*, pp. 20-28, Appendix A, pp. 63-65. Note the statistical results presented in the appendix are not those for the final fit used in the body of the bulletin pp. 20-28, i.e., the results presented in the appendix correspond to the fit obtained for the years 1928-40, 1947-52 with 1950 omitted also, giving an R^2 of .803. The coefficients derived in the body of the bulletin are estimated using data for the years 1928-40, 1947-53 with 1950 omitted with an R^2 of .8378. (See pp. 21 and 22.)

[4]Since the coefficients are not presented in the bulletin due to the matter noted in footnote 2 above, it was necessary to calculate them from the observations presented in *Ibid.*, p. 22. Neither were the standard errors of the coefficients presented for the final fit, but the coefficient for X_1 and X_4 were significantly different from zero at the .01 level by t-test and those for X_2 and X_3 were significant at the .05 level.

X_1 = Percentage of previous year's planted acreage abandoned before harvest due to weather or other growing conditions. (Assumed exogenous because predetermined during previous crop year).

X_2 = Square of index of expected income from corn and wheat as measured by net income per acre realized the previous year (exogenous).

X_3 = Square of index of cost of production of one acre of navy beans during current year. (Assumed exogenous since major factors in cost of production are largely influenced by factors outside the bean economy.)

X_4 = Log. of price received per cwt. by Michigan farmers for dry beans the previous year (exogenous).

There were several qualifications noted by the author for this equation. Firstly, there is a high correlation between X_2 and X_3 (.907) because of the similarity of the movements of the cost of producing these three crops. This reduces the reliability of the estimates of the parameters of these variables. Another qualification was that there are important variables not specified in the model which therefore enter the disturbance term. Undoubtedly, weather as it affects planting of the bean crop would be one such variable, but they could not be included because of difficulties of measurement. However, although this will reduce the reliability of the estimates of Y, it is not thought to have biased the estimates of the parameters. This is because the effects of weather over a number of years is likely to be random. In all, it was considered that the equation might prove a better estimator than is indicated by the coefficient of determination, R^2.

The Data

The data for the endogenous variable, acres planted, and the price variable were readily available in official published statistical sources. The percentage of planted acreage abandoned the previous year was calculated by taking the difference between planted acreage and harvested acreage as a percentage of planted acreage in that year.

The index of expected income from competing crops was calculated in the same manner as in the study.[5] Data for average yield per acre and average price received for corn and wheat in the area (multiplied together give average income per acre) are readily available from official sources. Income per acre was then divided by the cost of production per acre to give an index of expected income from that crop and the final index was obtained by taking the arithmetic average of these values for corn and wheat. The cost of production was originally computed for each year and is meant to allow for changes in practice through time. This was also the function of the index for the cost of production of dry beans.

Attempts made to extend these production costs data for the three crops involved, i.e., dry beans, corn and wheat, have been in the main unsuccessful. In computing the production costs for the years 1946-70 the following expenditure items, involving both direct cash costs and non-cash costs for each year were included. They were: seed, fertilizer, herbicide, farming expenses for machinery used in cultivation and harvesting, and machinery hire, which make up variable cash costs. Overhead costs included were: machinery ownership, real estate taxes, which both involve cash payments, and interest on the

[5] Ibid., p. 21.

operator's land investment which does not. Finally, all labor was considered as an aggregate including hired labor together with operator and family labor and charged at a single wage rate.

A major problem in computing the costs of production for the three crops, especially in the case of beans, was the lack of accurate data. This was most apparent in the earlier years of the period 1947-1970, for which costs were calculated. The costs at the beginning of this period are therefore underestimated relative to those calculated towards the end of it. As a consequence, the values arrived at probably fail to reflect changes in costs both over time and between the competing crops.

The newly constructed indices for the cost of production of dry beans and for expected income from competing crops were spliced with the corresponding indices used by Hathaway.[6] For neither index did the computed values appear very similar to those used in the original study. In agreement with the comments above, from 1954-1970 the index of expected net income from competing crops indicated a greater decline in the profitability of corn and wheat than actually occurred. Similarly, the cost of producing beans according to the index calculated has increased at an annual average rate of 5 per cent over this period, which is greater than experience indicates would be feasible.

Testing the Model

The procedure for testing the model was outlined in Chapter I and was demonstrated in detail for the underplantings model from the

---

[6]Note: Since in Hathaway, op. cit. there were no tabulated values presented for these indices it was necessary to read them from graphs which may involve some small errors.

burley tobacco study.[7] Therefore in evaluating this model only highlights will be discussed, otherwise the evaluation and conclusions will be the same as for the underplantings model. The object is to evaluate, on a preliminary basis, whether or not the model deals with verifiable forecasts obtained by a verifiable procedure based on the structural concepts involved in the planting stage for dry beans in Michigan. This latter aspect is the primary focus of this thesis.

Verifiable Predictions.--No definite conclusion could be made as to whether predictions for planted acres are verifiable. The first condition is fulfilled since a value for actual acres planted can be observed. Although the definition of the concepts involved in the variables is clear for most, there is some ambiguity as to exactly what concept of production costs was used in arriving at these costs for corn, wheat and beans, or what the definition of individual cost items was. Neither is it clear whether the average price received by farmers is in fact the annual average on a calendar basis or marketing year basis, or whether it is the preliminary price or the final price. Thus condition two is not fully met.

Similarly, the study did not make it clear when predictions should be made using the model. Both of these shortcomings undoubtedly derive from the fact that the main purpose of the model was to analyse the impact of government export programs over a given period, and not to make predictions.

An examination of USDA data for the variables of this model showed that final estimates (if it is assumed this represents the

---

[7] See above, p. 15 ff. and p. 25 ff.

actual figure) for planted acres is known by the end of December or approximately 6 months after the planting stage has been completed. However, in many years the estimates based on farmers' intentions in March before planting are within 1 per cent of the final figure. The model would be most useful if it could provide a forecast at least by this time. A preliminary survey of the data for the explanatory variables suggested this would be possible but that the values for the variables would probably not be very accurate. To determine the accuracy of the resulting forecasts would require more complete evaluation on an ex ante basis. This is not considered to be the domain of this thesis.[8]

Condition four regarding the ability to construct a confidence interval for point forecasts is met for the initial period. However, as will be seen below it could not be more rigorously tested for its validity in this period and it seems that the structural changes that took place would have eventually rendered the initial estimates of variance unreliable at some time after 1954.

Thus, in all, there is doubt as to whether the predictions from the model, as they stand, could be verified.

---

[8]There have been no estimates made on production costs since 1953 on a regular basis. In addition only a preliminary estimate (which is often inaccurate) for the previous year's average price to farmers is available by the December before the planting being predicted. The final figure is not available until the following December. (It appears that final average prices were the ones used in the study.) Estimates for harvested areas are first made in June or July prior to harvesting and this estimate is not officially final until December the following year, i.e. 18 months later. However, although there is considerable variation from year to year, it may be within 1 per cent of this figure by the previous December, i.e. 3 months after harvesting.

Verifiable Prediction Procedure.--While the theory upon which the model was based and data used in it may have been valid for the period in which it was fitted, the lack of reliable data prevents this from being verified by a more rigorous test.

There are some a priori grounds based upon behavioral economic theory, however, upon which it might reasonably be concluded that the model would have required modification after 1954. In 1956 new upright bean varieties were introduced, which quickly proved much less susceptible to weather and accompanying disease conditions than the old vine type varieties. This meant a certain amount of the uncertainty as to the final returns from beans was removed. This uncertainty had been characteristic of the entire period for which the model was fitted. With some of the uncertainty about the returns of a crop removed, it might be expected that farmers would be prepared to plant larger acreages of this crop given the same conditions of price, abandoned acreages the previous year, general costs of production, and expected income from the competing crops as previously experienced.[9] This indeed seems to be reflected in the higher numbers of actual acres of dry beans planted since 1956 as seen in Table 3.21.

Two other possible changes in the original behavioral relationships should be mentioned. The first is that it seems unlikely that after 1954 wheat would have had the same competitive relationship with dry beans as it did in the period for which the model was fitted. In

---

[9]See Harold R. Jensen, and Albert N. Halter, "Making of Decisions", A Study of Managerial Processes of Midwestern Farmers, Glenn L. Johnson, et al. editors, (Ames, Iowa: Iowa State University Press, 1961), Chapter 7, especially pp. 105-108.

1954 (also in 1950) rigid wheat acreage allotments were established, and have been in effect ever since. If the marketing quotas were filled each year (as they have been), there would be, most likely, a change in the price relationships which previously had existed between the three crops.[10] Similarly, starting in 1961, payments were introduced on corn acreage diverted from production for conservation purposes over and above the acreage diverted for this purpose in 1959 and 1960 by farmers.[11] This also is considered to have affected the competitive relationship that originally existed between these three crops.

While each of these factors discussed above may well have upset the predictive ability of the original model in later years, each of these changes should have quickly been obvious to users of the model at that time. They could have then made adjustments to the predictions and eventually to the model's coefficients and possibly to its explanatory variables, as they were suggested by the new behavioral relationships.

Summary

The analysis above, while far from conclusive, showed that there is a need for clarification regarding concepts used in defining the

---

[10]The details of the marketing quotas and acreage allotments over the years are quite complex, and marketing quotas, for instance were not announced between 1965 and 1970; but until 1970 at least there have been tight controls on the production of wheat. For details see USDA, ASCS, Compilation of Statutes, op. cit., 1969, pp. 65-80. Note especially p. 67, footnote 45 and discussion, and p. 76, footnote 61 and discussion.

[11]This was under the Soil Conservation and Domestic Allotment Act Sec. 16(c) added by PL 87-5, March 22, 1961, 75 Stat. 6, see Ibid., No. 242, 1963, pp. 124-134, and also ibid., 1969, pp. 157-160, for details up until 1970.

variables and when the forecasting would be done, if the model is to be used for predictive purposes. The main problem is that the model's first objective was not making predictions. If this had been the case, variables such as the previous year's price for beans might have been redefined so as to be available at an earlier date. In fact the average unweighted price for the 6 or 9 months prior to planting might have been a better guide on theoretical grounds as being the basis on which farmers make their decisions.

In a similar vein, if the model had been used on a regular basis, estimates of production costs could have been made with greater accuracy so that problems from lack of data would not have been encountered as they were in this study.

The model's structural specification could not be tested. If it could have been confirmed for the earlier period, a priori grounds were suggested which would have required it to be modified in later years. However, changes generally could have been anticipated and allowed for. In conclusion, though, the model as it stands does not provide a basis for making useful predictions.

2. The Yield Model[12]

The Model

In this model it was hypothesized that yield depends upon both planted acreage and prices the previous year. Since planted acreage was also considered to depend upon price (see the acreage planted model), a simultaneous relationship was suspected. Accordingly, in order to obtain combined estimates of the structure of factors

---

[12] Hathaway, op. cit., pp. 28-39 and Appendix B, pp. 65-67.

influencing bean yields in Michigan two simultaneous equations were used: acres planted estimated as it was in the previous section (the acres planted model) and then the yield equation estimated in its reduced form by ordinary least squares procedure. Data were fitted for the years 1928-40, with 1936 omitted, and 1947-52, with 1950 omitted, giving 17 observations and a maximum of 13 degrees of freedom with which to estimate the variance. The estimated structural equation is:

$$Y_1 = 2.237X_{11} - 121.7923X_4 - 1.9240Y_2 + 2005$$
$$(.0735) \quad (152.1850) \quad (.2441)$$
$$R^2 = .8582$$ [13]

Y_1 = Yield of unclean beans in Michigan (pounds per harvested acre).

Y_2 = Acres planted to dry beans in Michigan in the current year (thousands of acres). (Assumed endogenous because it is partially dependent upon price expectations as measured by price received the previous year.)

X_4 = Log. of price received by Michigan farmers for beans the previous year (exogenous). (Cents per cwt.)

X_{11}= Index of yield of unclean beans in pounds on Michigan State University (then Michigan State College), test plots with constant rotations, and with no direct applications of fertilizer on the bean crop. This variable is used to measure the influence of weather upon bean yields (exogenous).

---

[13] The constant term was not given and had to be estimated; neither was its standard error given. The decimal point for the coefficient of X_{11} is misplaced in the mathematical Appendix B. See *ibid.*, p. 67.

The main qualification made by its author for this model was the inability of the test plot yields, limited to a few sites in the state, to measure completely satisfactorily weather conditions which may vary considerably between different localities in Michigan. This is thought to have given rise to some unexplained yield variations, but since there is no reason to believe these measurement errors are not randomly distributed, it is believed the structural estimates of the other two variables are unbiased.

The Data

The data and their sources for this model are given in Table 3.21. There have been some changes in the basis on which the data are computed. Yields of dry beans were last reported on an unclean basis in 1954. Thereafter, they have been reported only on a clean basis. In order to obtain unclean yields with which to test the model, it was necessary to convert clean yields to an unclean basis using the per cent dockage for Michigan dry beans 1955-70. Dockage is no longer available for these years based on the same size sample as previously.[14] However, as far as can be judged, the more recent series appears to be entirely consistent with the values in the previous series. It is therefore assumed that there are no errors in the dockage figures since 1955. This in turn gives rise to consistent values of unclean production for the period 1955-70 and 1954.

---

[14]The present dockage for dry beans in Michigan 1955-70 was obtained from personal correspondence with Glenn A. Swenson, Agricultural Statistician, Michigan Crop Reporting Service, USDA, Lansing, Michigan, June, 1971.

A weather index was computed for the years 1957-70 which allowed four years with which to "splice" the values of the new index with those used in the original study (1947, 1948 and 1951, 1952). The index was compiled on a slightly different basis than that used by Hathaway.[15] In this case it was only possible to use plot yields from one location. It is thought, however, to be representative of a major portion of the important bean area of the Saginaw Valley, including over 80 per cent of Huron and Midland counties, all of Tuscola, Gratiot, Saginaw and Bay counties and a portion of Sanilac, Shiawassee, and Clinton counties, but excluding Isabella, Montcalm and Ingham counties.[16] These are the 12 top bean producing counties. In fact this difference is thought to favor the new index since at least for some years the index used by Hathaway was based solely on East Lansing data,[17] which would give a less accurate measure of the effect of weather in the major bean producing area. However, there must be expected to be a continuation of the problems mentioned in the original study of not measuring weather effects correctly over the entire area mentioned above in some years.

Another difference is that the original index was based on check plot yields in fertilizer experiments with beans. The present index is based upon the average yield values for three different types of bean rotations each of which had four replications. Each rotation

---

[15]See Hathaway, op. cit., p. 29.

[16]This conclusion is the result of discussions with Wayne M. Adams, Professor, Department of Crop and Soil Science, Michigan State University, Summer, 1971.

[17]See Hathaway, op. cit., p. 34.

and each replication within the rotation was the same throughout the entire period 1947-70, and received the same fertilizer applications. The only changes made over the period were two changes in the variety of dry beans used. The first was a replacing of the Michelite vine type variety by the Sanilac upright variety in 1965 and this by a new type of Sanilac in 1968.[18]

The inclusion of three different rotations seems to be advantageous, as the more averaging out of factors other than weather, the more likely the index will be to reflect just the weather effects and it should also gain stability. There was also some upward trend apparent in yields, due to the improved varieties used, which was removed by taking variations due to weather as being the difference between the expected values for a regression line fitted to the data and observed values of yield.

The new index appears to correspond reasonably satisfactorily with the old index for the years in which they overlap. However, as already warned, the index in some years does not adequately measure the weather conditions for the entire bean producing area as will be seen below.

Testing the Model

This follows the format established for the models above.

Verifiable Predictions.--As for the other models the first condition is obtained, and so is the second except for a comment regarding the

---

[18]The data for the test plot yields were obtained from Ray L. Cook, Professor Emeritus, Department of Crop and Soil Science, Michigan State University, "Experimental Records of the Ferden Farm". These were for dry bean rotations, 3 (low nitrogen), 6 (low nitrogen), and 7 (low nitrogen) from 1952 onward. In the years 1947-51 these same treatments were known as the high nitrogen treatments.

TABLE 3.21.--MICHIGAN DRY BEANS, YIELD MODEL: DATA USED, PREDICTIONS OBTAINED, 1927-1970

Year	Yield of Unclean Beans: Actual[c] (pounds per acre)	Yield of Unclean Beans: Predicted[d] (pounds per acre)	Weather Index: Original[e] (percent)	Weather Index: Recent[f] (percent)	Price[g] (cents per cwt)	Acres Planted in Dry Beans[h] (thousands of acres)
1927[a]					500	
1928	660		65.0		740	600
1929	560		53.1		620	575
1930	420		65.0		435	743
1931	560		53.0		180	690
1932	920		88.0		150	569
1933	730		91.0		225	573
1934	661		81.4		275	665
1935	890		131.0		225	565
1936	570				600	576
1937	910		105.0		255	472
1938	980		142.0		185	477
1939	988		81.7		280	499
1940	760		103.0		350	618
1941	770			91.3	455	791
1942	1030			66.1	480	593
1943				78.3	590	655
1944	690			26.9	600	701
1945	820			64.5	620	435
1946	740			71.1	960	531
1947	670		33.0	51.0	1240	494
1948	880		92.0	75.2	720	514
1949	1100			125.2	590	529
1950	950			86.0	670	503
1951	1120		95.0	88.5	690	392
1952	1120		50.2	55.5	770	349
1953[b]	1050	1256		152.8	790	384
1954	910	899		86.6	930	492

1955	938	820		80.6	690	522
1956	1125	838		77.3	660	517
1957	796	787		53.9	770	517
1958	1010	844		109.7	650	548
1959	1355	828		98.2	560	548
1960	1223	909		117.0	590	532
1961	1412	836		103.7	640	553
1962	1322	740		87.0	630	581
1963	1502	783		116.0	650	593
1964	1336	712		116.0	670	629
1965	1012	383		18.7	820	686
1966	1326	539		58.0	640	645
1967	1100	764		74.3	840	554
1968	1080	670		91.2	800	615
1969	1241	616		129.8	620	689
1970	1102	621		96.5		655

[a]Data used for fitting the model 1927-52.

[b]Data used for testing the model 1953-70.

[c]Col. 1. Yield of unclean dry beans in Michigan: 1928-53, Michigan Department of Agriculture, Michigan Agricultural Statistics, (Lansing: various issues). (Note where there was considerable variation in estimated for a year the most recent available was taken.) 1952-70, estimated from clean yields, see p. 49, footnote 41.

[d]Col. 2. Unclean yield: computed from equation p. 45.

[e]Col. 3. Weather index from test plot yields of dry beans: 1928-35, 1937-46, and 1947, 1948, 1951 and 1952, from Hathaway, op. cit. read from Figure 10B, p. 32.

[f]Col. 4. Weather index computed from test plot yields of dry beans: 1941-70, p. 49 and 50 including footnote 7.

[g]Col. 5. Average price to farmers for dry beans in Michigan: Michigan Dept. of Agriculture, op. cit.

[h]Col. 6. Average planted to dry beans in Michigan: ibid.

definition of the price variable similar to that made concerning this variable in the planting model.[19]

As also seen in that model, it is not clear from the study when the yield model would be used for making predictions. An examination of the USDA yield estimates indicated that a preliminary estimate is available by July or August for the coming harvest season. The final value is given 12 months later. For the sample analysed, many of the preliminary estimates were within 1 per cent of the final yield. Therefore the model would be useful if it could provide reliable estimates before this time. This should be possible. Final figures for all three explanatory variables would be available by the January following harvesting in September. However, weather data should be available by mid-September, and planted acreage is nearly always known within 1 per cent of the final figure by this time. Price for the previous year would still be inaccurate, but if this was redefined on an unweighted average basis as suggested above[20] more timely (and even more accurate) forecasts might result.

With condition four also met this preliminary analysis suggests that the predictions made by this model are verifiable, at least initially.

Verifiable Forecast Procedure.--At first the conditions for a verifiable prediction procedure appear to be met by the model. This conclusion is now subjected to a more rigorous testing especially

---

[19] See above, p. 82.

[20] See above, p. 83, footnote 8 and p. 88.

with regard to the model's structural validity. As before this is accomplished by a qualitative investigation based on the forecast errors.

When the forecast errors for the years 1954-70 over which the model is being tested are observed and compared with the residuals for the period fitted, illustrated in Figure 3.21,[21] it appears that the model performs within the error limits of the values of unclean beans predicted in the original sample for the first four years 1954-58. A positive bias in the forecast errors, i.e. underestimation of the actual values of unclean yield per harvested acre of dry beans, is indicated on a probability basis. However, this does not appear to be significant as far as indicating any deterioration in the predictive ability of the model from that which it displayed for the original sample. For instance, between the years 1948 and 1952 there are five consecutive positive residuals.

Beginning in 1959 at least, however, forecast errors had become large and positive with yields being underestimated by an average of 550 pounds per acre over the next 12 years. This indicates a major change in the behavioral relationships from those existing when the model was fitted.

Hathaway demonstrated that the apparent steady increase in bean yields over time was due to decreases in planted acreage of beans (production confined to better land and more skillful managers), rather than improvements in technology.[22] In fact when a simple

---

[21] See also Hathaway, _op_. _cit_., Figure 11, p. 34 for earlier years.

[22] See _Ibid_., p. 28 and p. 35.

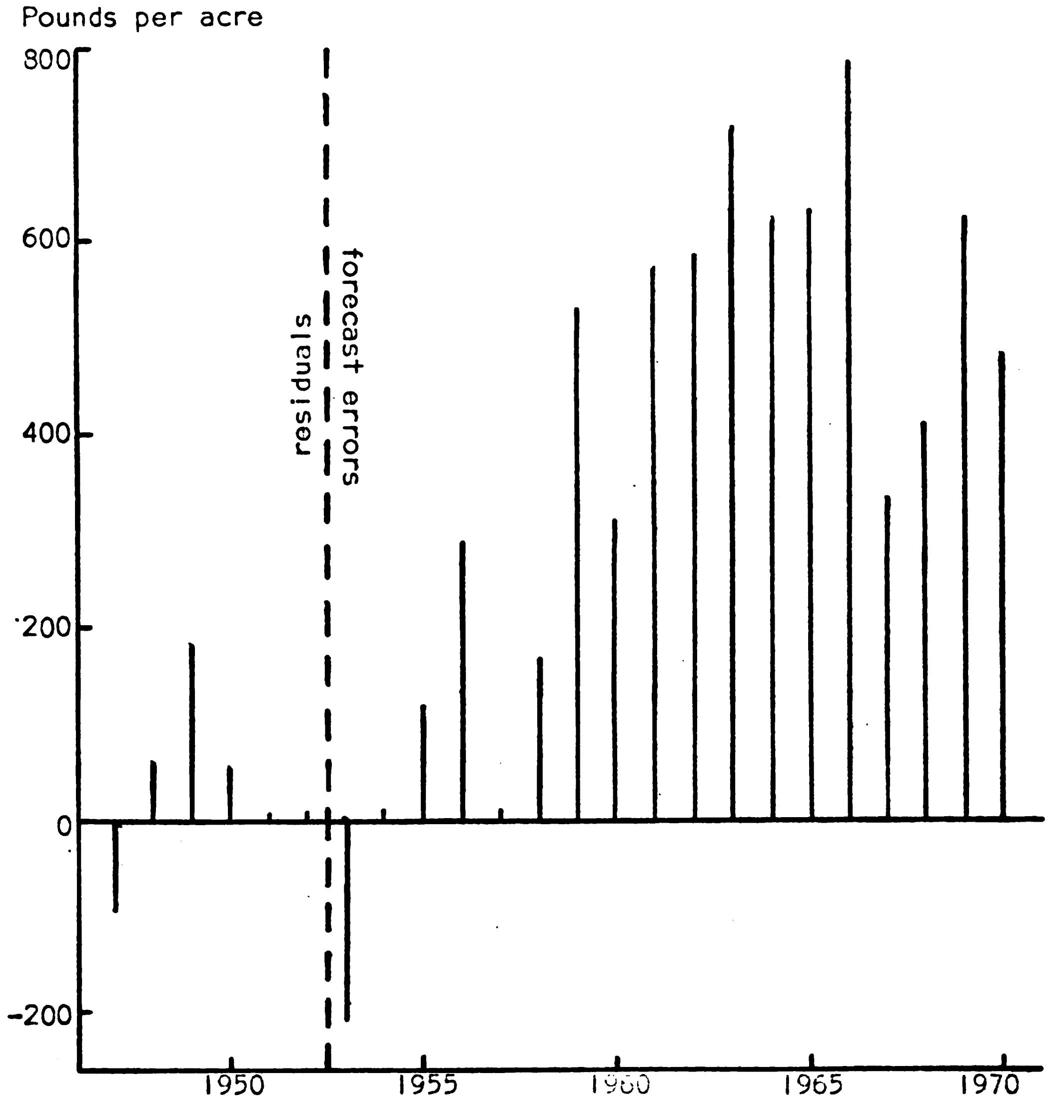


FIGURE 3.21 -- Michigan dry beans, yield model: residuals 1947-1953 and forecast errors 1954-1970.

regression on time was fitted to the data for the number of acres planted for the years 1928-53, for which the model was fitted,[23] the coefficient indicated an average rate of decrease of about 2050 acres a year. For the period 1954-70 used to test the model, a similar procedure indicated average annual increases of planted acreage of about 2620 acres a year.[24] This relationship is illustrated in Figure 3.22. In spite of this, and the fact that absolute levels of planted acreage were higher than in any year since the end of World War II, beginning in 1956 there were 9 record years for yield as shown in Figure 3.23. In addition, the three previous record years, 1949, 1951 and 1952, all coincided with either record low plantings or better than average weather conditions.

The most satisfactory explanation for this behavior would seem to be the introduction of the Sanilac bean in 1956. As was mentioned above,[25] this is a bush or upright type bean in contrast to the spreading vine habit of Michelite, the previously most popular pea bean in Michigan. This latter type of bean is much more susceptible to weather conditions which induce fungus diseases when the plants are not well aerated. It is hypothesized the improved characteristics of the new variety had two effects. Its improved yield gave higher, more certain returns to farmers who therefore tended to increase the acreage of beans they grew. Secondly, areas, which from a micro-climatological standpoint, had been marginal for production of the

---

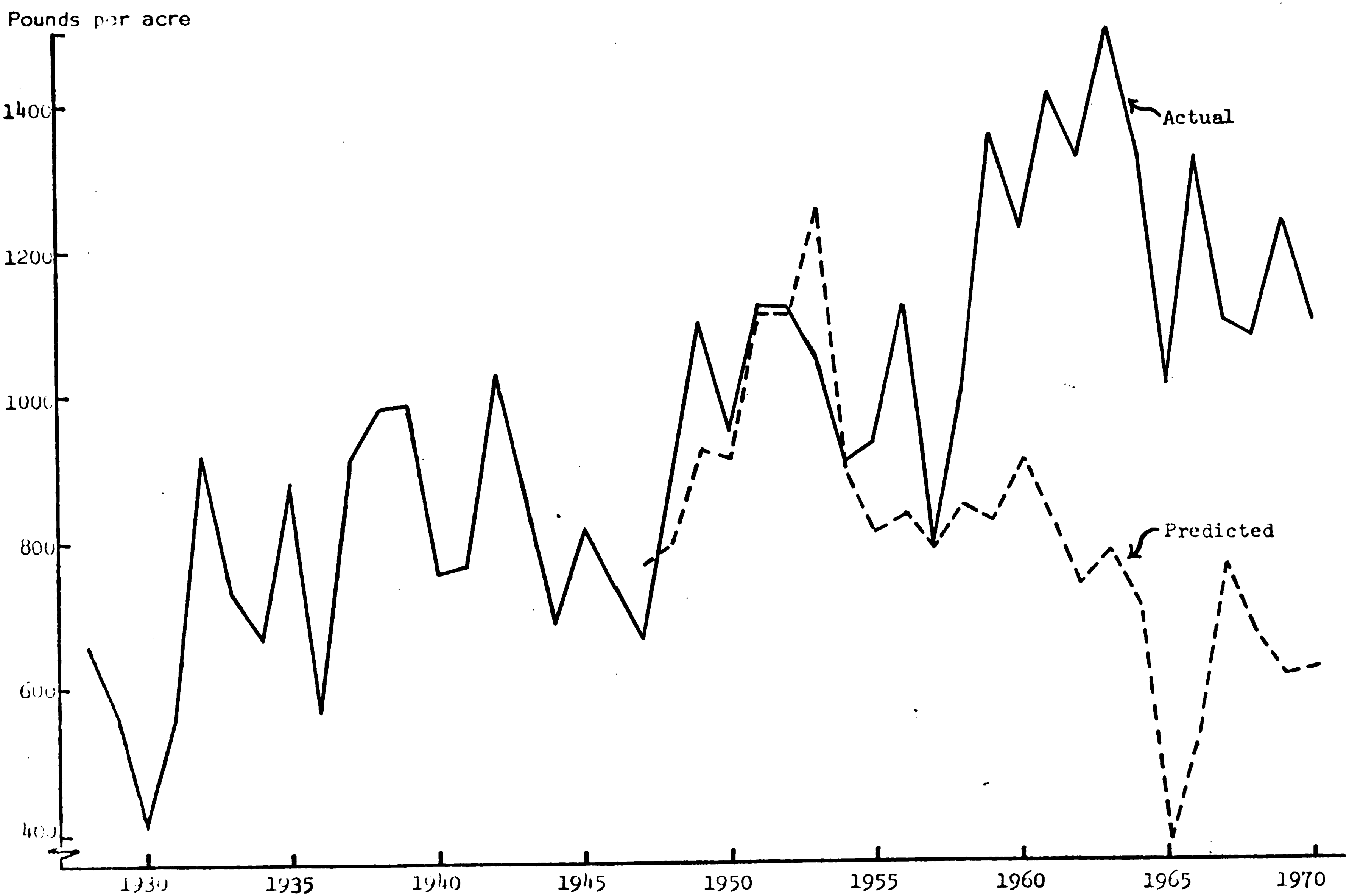
[23] Excluding 1936 and 1950 and 1941-46.

[24] It should be noted, however, both coefficients were only significantly different from zero at the 10 per cent level by t-test.

[25] See the acres planted model p. 84.

Source: See Table 3.21

FIGURE 3.22 -- Acres planted in dry beans in Michigan 1928-1970.



Source: See Table 3.21

FIGURE 3.23 -- Yield of unclean dry beans per harvested acre: actual 1928-1970 and predicted 1947-1970.

Michelite bean, were no longer so when the bush type variety was used, giving rise to higher or at least comparable yields in spite of the expanded total acreage of beans.

Greater weight for this conclusion is evident when conditions in 1957 are investigated more thoroughly. This shows that the very small forecast in this year might have been larger had it not been for exceptionally poor weather conditions. The weather index indicates this, but not fully. This is because weather effects on the dry bean crop are often localized. In this year there was considerable flooding damage early in the season, later pervasive dry weather conditions, and finally considerable damage at harvesting time.[26] The weather index, based as it is on one location cannot indicate the extent of weather effects for the whole dry bean area accurately. Hence, the conclusion is that it underestimated climatic effects in 1957. Judging from crop reports, it also overestimated the effects of bad weather in 1960, 1967, 1968 and 1970, and in 1963 and 1966 the weather was better than indicated by the index. This would substantially explain departures from the new trend inferred by the forecast errors for these years.

Other factors which may have caused the higher than predicted yields also occurred. Manganese deficiencies were discovered in some bean areas in the early 1950's. Similarly, in the early 1960's zinc deficiencies were found to occur on some of the calcareous soils with relatively high pH's in the Saginaw Valley. Both of these deficiencies could be overcome inexpensively. However, since it is only under

---

[26] See USDA, Agricultural Marketing Service, Crop Reporting Board, Crop Production: Annual Summary, Dec. 1957, (Washington, D.C.: Dec. 1957), p. 23.

more extreme conditions that these deficiencies would have any marked effect on dry bean yields, their effect on the general increase in yields is probably very small.

There was also an increase in the use of "N.P.K." fertilizers. The percentage of the acreages of the dry bean crop fertilized increased from 65 per cent in the census year 1954 to 86 per cent in 1964. This increase is even more spectacular when the average rates applied per fertilized acre are examined for dry beans. This showed an increase of 70 per cent in the use of elemental nitrogen between 1954 and 1959 and a further 100 per cent increase from 1959-1964. Similar increases were evidenced for elemental phosphate and potassium.[27] This factor is connected with the introduction of the new bean variety. These varieties give good responses to fertilizer, in particular nitrogen, whereas the former Michelite variety did not.

Another factor that should be noted is the great increase the use of herbicides for weed control in dry beans between 1963 and 1965. This is a case where, most likely, the overall effect has been a substitution of one input for another, in this case labor, rather than a technological advance causing an increase in yields.

Finally it appears likely that a forecaster using the model could have been quickly aware of the influence of the new variety and generally made allowances for it. Experience with the use of the weather index and knowledge of conditions during the growing season would probably have allowed him to modify it to better represent

---

[27]See Richard D. Duvick, Trends in the Use of Major Fertilizer Nutrients on Michigan Cropland and Pastures, Agricultural Economics Report No. 88, Dec. 1967, (East Lansing: Department of Agricultural Economics, Michigan State University, 1967), p. 6 and Table 5, p. 10.

the true influence of weather. However, a more complete answer to the problem to ensure the statistical validity of the forecasts would be to locate additional test-plot sites so that the bean producing area is more fully represented.

Summary

This preliminary analysis has shown, that in the main, the yield predictions are verifiable. As was seen for the acres planted model, however, this model also demonstrates deficiencies in the definition of some of the explanatory variables[28] and the timing of forecasts, which appear primarily because the model was not constructed with this objective in mind.

On the other hand, the analysis verifies that the model as specified does reflect the structural relationships involved in determining dry beans yields for the years used in estimating it, and until 1953 afterwards. In 1956 the introduction of a new upright variety of bean, which was less susceptible to disease, and which, unlike the earlier variety, gave good responses to fertilizers, caused a substantial increase in yields. Relatively, the other developments which were mentioned above seem to have had very little effect. When the influence of the new variety and the inadequacies of the weather index are allowed for, most of the departures indicated by the forecast errors appear to be explained.

In all, the model should warrant modification and reestimation incorporating these suggestions, and then more rigorous testing on an ex ante basis to determine the accuracy of its forecast.

---

[28]Examples for this model were the price variable and lack of precise information on the locations of the test-plots for weather index measurements.

3. The Price Model[29]

The Model

This model consists of two structural equations which, because of the joint, interdependent relationships between the price of dry beans and the amount of beans delivered to the government under the price support program, were estimated as a simultaneous equation system in their reduced form and then converted to their structural form. The equations were as follows in their structural form:

$$Y_1 = .2299Y_2 - .4147X_2 + 4.4335X_3 + .2739X_4 + 638.5185$$

$$Y_2 = \underset{(.7163)}{2.8543X_1} + \underset{(.1247)}{.8566X_2} - \underset{(2.6615)}{7.4313X_3} - \underset{(.0988)}{.4934X_4} - 1925.1197$$

$R^2 = .8797$ [30]

Y_1 = The average price received by Michigan farmers for dry beans, in cents per cwt. (assumed endogenous).[31]

Y_2 = The amount of beans delivered to the government under the price support program, in thousands of cwt. (assumed endogenous because it is dependent on market price).

X_1 = The support price in cents per cwt. (endogenous measured in actual values.

X_2 = Supply of pea and medium white beans available in the U.S., in thousands of cwt. (exogenous). Includes both current production and non-government carryover.

---

[29] Ibid., pp. 39-51 and Appendix C, pp. 67-69.

[30] Note: No standard errors or coefficients of determination were presented for the first equation and no standard error was presented for the constant term in the second.

[31] Note: The "free market" price, Y_F, is defined as the price of dry beans when there is no government support program, i.e. $Y_F = .2299(0) - .4147X_2 + 4.4335X_3 + .2739X_4 + 638.5185$

X_3 = Disposable consumer income in the U.S. in billions of dollars (exogenous). Used as an indicator of general price level.

X_4 = Supply of Great Northern beans available in the U.S., in thousands of cwt. (exogenous). Includes both current production and non-government carryover.

The equations were fitted to data for the years 1932-41 and 1946-52. This gives 18 observations and a maximum of 13 degrees of freedom with which to calculate the variances.

The sign of the regression coefficient for the supply of Great Northern beans is the opposite of what would be expected, probably due to the high intercorrelation between this variable and disposable consumer income (.79). This means that neither this coefficient nor that for disposable consumer income are likely to be structural. However, the regression coefficients for the remaining two variables do appear to be structural. It was warned that the "fairly high predictive accuracy for the period studied"[32] might not continue should the relationship between the supply of Great Northern beans and consumer income change.

The Data

The data for the model and their sources are given in Table 3.31, but there are some limitations that should be noted. These involve the data for non-government carryover for pea beans and Great Northern beans. Official estimates appear to be available only on an aggregate basis for all dry beans with no breakdown by variety.

---

[32] *Ibid.*, p. 69.

TABLE 3.31.--MICHIGAN DRY BEANS, PRICE MODEL: DATA USED, PREDICTIONS OBTAINED, 1927-1970

Year	Average Price of Dry Beans Actual[c] (cents per cwt)	Average Price of Dry Beans Predicted[d] (cents per cwt)	Govt. Takeover of Pea Beans Actual[e] (thousands cwt)	Govt. Takeover of Pea Beans Predicted[f] (thousands cwt)	Support Price for Pea Beans[g] (cents/cwt)	U.S. Production of Pea Beans[h] (thousands cwt)	Disposable Personal Income[i] (billions $s)	U.S. Production of Great Northern Beans[j] (thousands cwt)
1927[a]	500							1208
1928	740				720	3173	84.0	1387
1929	620				600	3262	83.1	1747
1930	435				415	3063	74.4	2011
1931	180				160	3663	63.8	1956
1932	150				130	5214	48.7	992
1933	225				215	4237	45.7	1440
1934	275				255	4102	52.0	1084
1935	225				205	4803	58.3	1441
1936	600				580	2235	66.2	1470
1937	255				235	4337	71.0	2162
1938	185				165	4503	65.7	1712
1939	280				260	4275	70.4	1533
1940	350				330	3971	76.1	1768
1941	455				435	4855	93.0	5335
1942	480				460	4908	117.5	5300
1943	590				570	4969	133.5	5343
1944	600				580	4422	146.8	2477
1945	620				600	2687	150.4	2481
1946	960				940	3814	159.2	3440
1947	1240				1220	3074	169.0	3554
1948	720		640		740	4476	187.6	4039
1949	590		1845		645	5334	188.2	3204
1950	670		10		622	3356	206.1	1724
1951	690		1130		689	4072	226.1	1484
1952	770		260		770	3412	236.7	1927
1953[b]	790	848	377	602	775	3607	252.6	1819
1954	930	1025	0	74	721	3158	257.4	2025
1955	690	680	623	751	648	4475	275.3	1948

1956	660	735	1667	1139	643	5020	293.2	1809
1957	770	1023	31	-272	634	3358	308.5	1501
1958	650	521	9	796	622	5042	318.8	2035
1959	560	278	178	1229	553	6065	337.3	2256
1960	590	621	1838	1290	556	5845	350.0	1576
1961	640	283	1612	2109	625	6755	364.4	1678
1962	630	182	964	2031	625	6725	385.3	1469
1963	650	135	1012	2244	625	7609	404.6	2282
1964	670	374	602	1571	625	6785	438.1	1711
1965	820	856	1	301	615	5480	473.2	1432
1966	640	804	1677	1309	615	7290	511.9	1949
1967	840	1487	0[k]	-913	600	4787	546.5	1500
1968	800	1309	0	-506	590	5615	591.0	1383
1969	620	922	0	392	590	7224	634.2	1707
1970	960	1920	0	-1595	590	5229	687.8	1463

[a]Data used for fitting the model.

[b]Data used for testing the model.

[c]Col. 1. See Col. 5, Table 3.21.

[d]Col. 2. Predicted price: computed using equation p. 102.

[e]Col. 3. Pea beans delivered to the government under the price support program: 1948-51, Hathaway, _op. cit._, read from Figure 15B, p. 48, 1952-70, George Parker, Agricultural Statistician and Conservation Service, USDA (East Lansing), personal correspondence August 2, 1971.

[f]Col. 4. Predicted government takeover: computed using equation p. 102.

[g]Col. 5. Support price to farmers for U.S. No. 1 grade pea beans: government support price on No. 1 grade U.S. pea beans, George Parker, _op. cit._, less handling charge, obtained from personal interview, Dale Kingsley, Michigan Elevator Exchange, Division of Farm Bureau Services, (Lansing: June, 1971).

[h]Col. 6. U.S. production of pea beans (clean bases): USDA, _Agricultural Statistics_, _op. cit._, various issues.

[i]Col. 7. Disposable consumer income, U.S.: U.S. Department of Commerce, Office of Business Economics, Business Statistics, Biennial Edition, various years (Washington, D.C.: odd years).

[j]Col. 8. U.S. production of Great Northern beans (clean basis): USDA, _Agricultural Statistics_, _op. cit._

[k]Carryovers insignificant from 1967-1970 and thus assumed to be zero.

This difficulty is substantiated by Hayenga[33] who reports from interviews with navy bean growers, two information lacks; "There are too few estimates of crop production made as the growing season progresses" and ". . . There is no information on bean stocks or inventories at any level of the market (except for CCC holdings) to supplement the crop production estimate and obtain an accurate estimate of effective supply at any one time during the year." An attempt was made to estimate navy bean carryover for Michigan, which grows over 98 per cent of the navy beans produced in the U.S., from figures for dry bean inspections (i.e., official inspections of all dry-beans that are sold to commercial interests, local or overseas, or to government).[34] The results seemed most inconsistent, which was born out by a failure of more sophisticated attempts at estimating carryover figures.[35]

Finally, Vandenborre presents figures for commercial carryovers of dry beans, broken down by variety,[36] including navy beans and Great Northern beans for the years 1948-63. A comparison of these carryover

---

[33]Marvin L. Hayenga, Structure and Problems of the Navy Bean Marketing System, Michigan State University Agricultural Economics Report 91, East Lansing, April 1968, p. 24.

[34]Michigan Bean Shippers Association, "Summary of Official Inspections," (Saginaw: from personal correspondence, June 1971).

[35]This is based on discussions with Marvin L. Hayenga, Associate Professor Agricultural Economics, Michigan State University, East Lansing on his work on this problem.

[36]Roger J. Vandenborre, An Econometric Investigation of the Impact of Government Support Programs on the Production and Disappearance of Important Varieties of Dry Edible Beans, Giannini Foundation Research Report No. 294, California Agricultural Experiment Station, (Berkeley, California: December 1967), Appendix 3, p. 88.

figures with those used by Hathaway in the years 1948-52, in which the two data series overlap,[37] indicated two alternatives.

Vanderborre shows commercial carryovers, varying between 1 and 13 per cent of total production for both bean varieties, which occur consistently in all years between 1948 and 1963, so that the conclusion would be that there were significant commercial carryovers in all years, at least up until 1963. Hathaway's figures indicate no carryovers from 1948-52 and for the purposes of this study this finding was extrapolated for the period 1953-70. The latter alternative would be consistent with the industry's desire to avoid carryover because beans do not store well.

With this in mind, and from the results of a preliminary analysis comparing the forecast errors for the two sets of data when used in the model,[38] no carryovers were assumed for the period 1948-70. This provides data which allows at least partial evaluation of the model's performance.

Testing the Model

Bearing in mind the limitations in the data noted above, the evaluation of the model follows the procedure set out in Chapter III and demonstrated with respect to the various other models analyzed.

---

[37]The Michigan dry bean study (Dale E. Hathaway, _op. cit._) presents no statistical appendices. Rough approximations of the values of supply of navy beans were read from graphs (_Ibid._, p. 45, Figure 13B and p. 47, Figure 15). There was no basis for arriving at supply of Great Northern beans used in the study.

[38]This showed that using no carryovers gave slightly better though similar results to those obtained using Vanderborre's data. It also showed, that in either case, the errors from this source were small relative to others that appeared to be involved.

Verifiable Predictions.--Conditions one and two are met. The third condition regarding the definition of time interval is not clear, reflecting the fact that making predictions was not the prime object for which the model was constructed. A preliminary examination of the data required for making forecasts, indicated that since 1952 at any rate, it would be available by January for the marketing year September 1 to August 31, the main limitation being data on supply. This is because estimates of production for both classes of beans are not very accurate by this time[39] and commercial carryover figures are unreliable. Estimates of the two dependent variables, price and government deliveries, are available by July for a given marketing year for the latter, though they are often not within 1 per cent of the final figure until 6 months later. For price of Michigan dry beans it is difficult to obtain a clear indication when the first reliable estimates are available, but possibly not until the final estimate is given in January the following year.[40] Thus the model's predictions could be very useful if they were sufficiently accurate.

The last condition regarding probability intervals is met initially though inaccuracies in the data for some of the explanatory variables, notably commercial carryovers, cause some reservations as to their validity on statistical grounds.

---

[39]Unless the planted acreage model and yield model were able to produce more accurate estimates of pea bean production.

[40]The support price has been announced by February in the earlier years becoming later until currently it is not announced until the beginning of May. Production estimates as indicated by Crop Production, op. cit., various issues, are available beginning in July of August prior to the opening of the market year, but are not reliable within 1 per cent until between 12 and 18 months later. Disposable income is available quarterly as well as annually with a reliable estimate for the annual statistic available in January (at least since 1949).

Verifiable Forecast Procedure.--Initially, the logic or theory on which the model is based appears sound, so that apart from some question as to whether reliable data exists for commercial carryovers by variety, the conditions for a verifiable procedure would be met.

As before this criterion is now put to a more rigorous test.

When the forecast errors for the price equation are examined, it appears that it performed acceptably for 4 years after it was fitted, or until 1956. Then, as can be seen in Figure 3.31, the errors become at first increasingly large and positive and then strongly negative. This suggests positive autoregression which was born out by a Durban-Watson statistic indicating this conclusion is significant at the 5 per cent level for the period 1948-63 and at the 1 per cent level for the period 1948-70.

When the performance of the equation predicting beans delivered to the government under the price support program (government takeover) is similarly examined, it shows acceptable behavior until 1955, i.e., three years after the last year fitted. The forecast errors were large in all years with a heavy negative bias as can be observed in Figure 3.32. This indicates general overestimation of government takeover of dry beans. A test for autoregression using a Durbin-Watson test statistic proved inconclusive.

Generally, the poor predictive performance of the model as a whole is probably due to a number of changes in this sector of the dry bean industry. This would include both changes that have occurred in the relationships originally specified in the model, as well as the introduction of new factors.

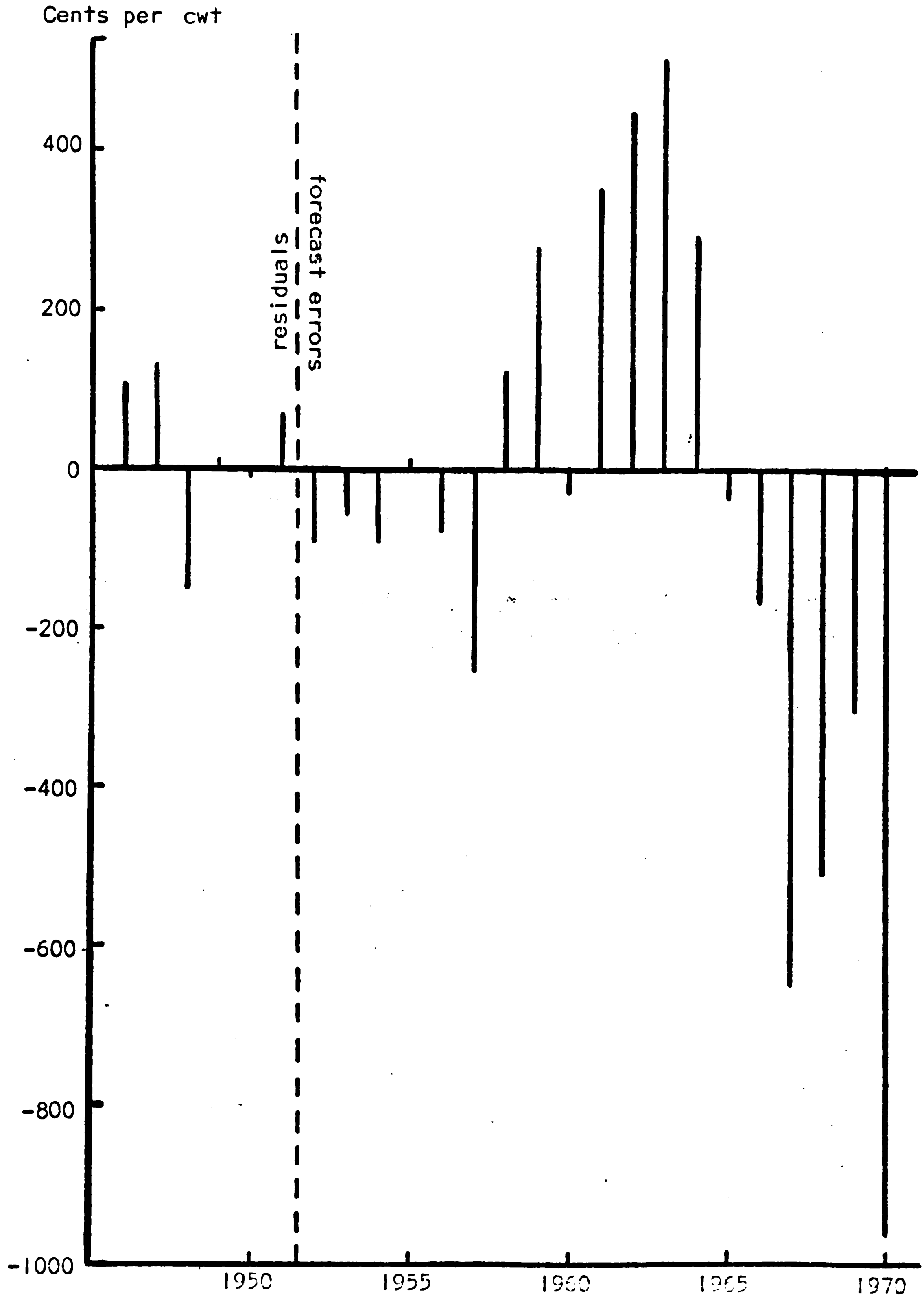


FIGURE 3.31 -- Michigan dry beans, price model: residuals 1946-1952 and forecast errors 1953-1970 for price of dry beans.

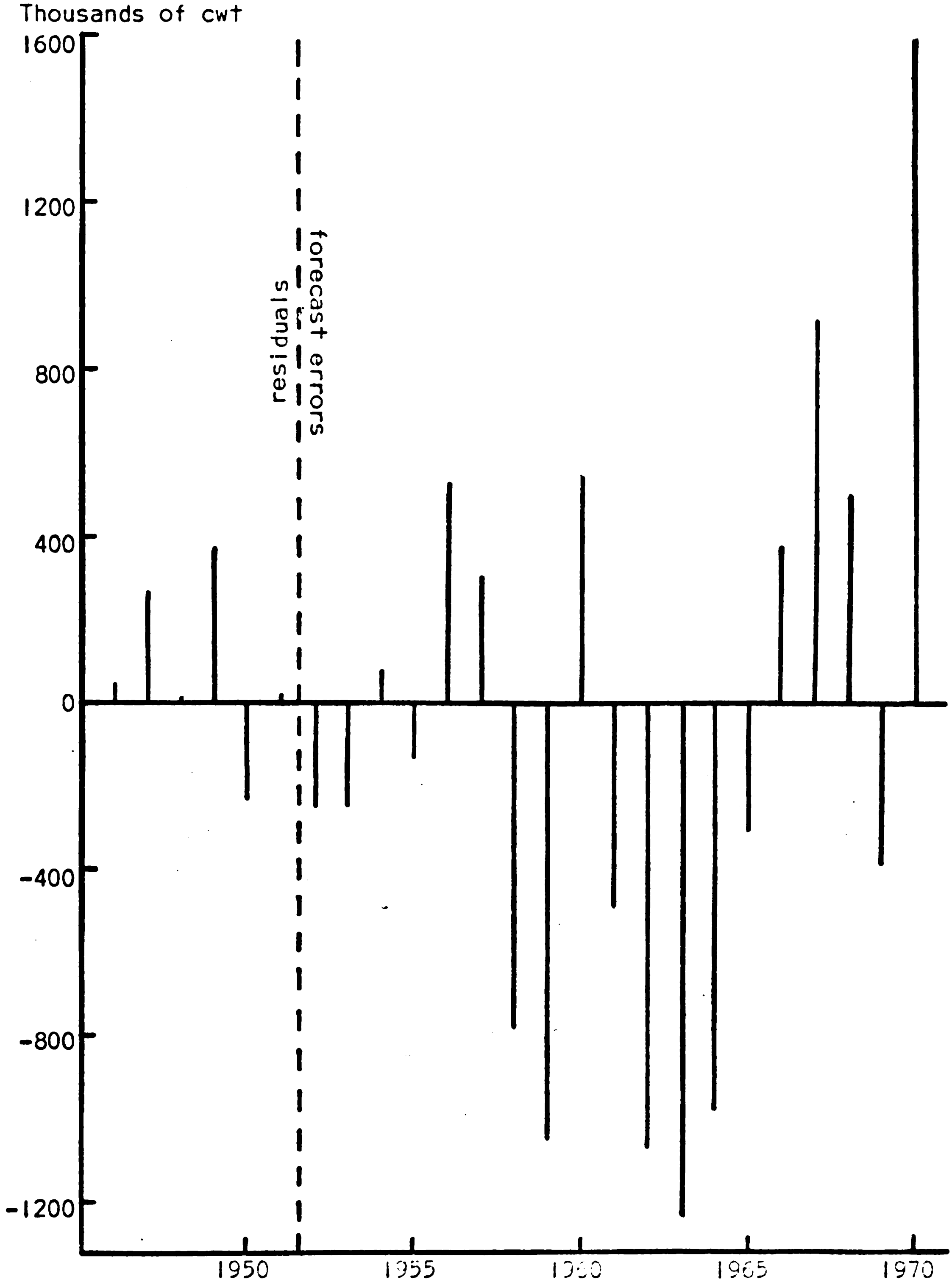


FIGURE 3.32 -- Michigan dry beans, price model: residuals 1946-1952 and forecast errors 1950-1970 for quantities of pea beans acquired by the government in price support operation.

A. Changes in Behavioral Relationships Included in the Model. The first relationship to be upset was that specified in the variable for Great Northern beans which, as it existed, had a non-structural significance.[41] It was suspected of affecting the residuals for the price equation in 1948, 1951 and 1952.[42] When Krebs attempted to include a variable for the supply of Great Northern beans in a relationship explaining domestic demand for navy beans, he found no significant relationship for the years 1951 to 1967.[43] A likely explanation for this seems to be the decline of the importance of the dry bean retail trade, which is now very small and in which Great Northern beans compete almost exclusively, while navy beans are used mainly in canned bean products which are now the primary intermediate uses of dry beans in the U.S. This is possibly reflected in the annual production data for Great Northerns (see Table 3.31) which declined to a low and since relatively constant level, in 1950. On the other hand, as can be seen in Table 3.31, the production of navy beans has steadily increased since that time.

Chronologically the next relationship to change is at least partially accounted for in the production variable. Up until 1956 there had been very little change in varieties of navy beans. However, in this year a new variety was introduced. Being an upright variety, instead of the traditional vine type, it proved to be much less prone to

---

[41] See the discussion on p. 103.

[42] Dale E. Hathaway, op. cit., p. 49.

[43] Edward H. Krebs, "Simulated Price and Supply Control Programs for the Michigan Navy Bean Industry," Unpublished Ph.D. dissertation, Department of Agricultural Economics, Michigan State University, 1970, p. 30.

weather conditions and fungus diseases. This had the effect of considerably reducing the uncertainty element for which dry bean crops are notorious, and thus both indirectly as well as directly reducing the costs of producing navy beans. A large increase in production occurred as illustrated in Table 3.31. This may be partially responsible for the underestimation of price in the years 1958, 59, 61, 62, and 63 as can be seen in Figure 3.32. It seems almost certain that the introduction of the new bean varieties beginning in 1956 was the disturbance which set off the positive autocorrelation in this period.

Beginning in 1963, there appears to be a change in the original relationship expressed by the disposable personal incomes variable. From the start, this variable was not considered entirely satisfactory as it contains two elements which are hypothesized to effect the price of beans: the general price level, and changes in real income.[44] Disposable income increased, from 1963 onwards at an annual average rate of 10 per cent for the period 1963-1970, compared with 5.4 per cent in the previous 7 years.[45]

Assuming the same average supply conditions as in previous years, if the relationship estimated between this variable and price is still correct, an increase in the real and actual price of beans should have occurred, since this indicator suggests both an increase in actual

---

[44]See Hathaway, op. cit., p. 41.

[45]The annual 10 per cent increase comprises an average increase of 5.1 per cent inflation and 4.8 per cent real income for the period. In the first 2 years there was a marked increase in real income with little inflation (approximately 1 per cent as measured by the consumer price index). After this the rate of annual inflation increased until it was 5.5 per cent in 1970.

demand and in the rate of inflation of the price of beans. Actual prices for beans did inflate, but although the model indicated an average real price of beans for the period of $2.76, the actual real price was $2.19, exactly the same as for the previous 7 year period, which means there was no apparent increase in demand.

In reality an even greater departure is indicated. For this period, beginning in 1965, beans were actually in short supply because of poor seasonal conditions for production. This apparently depleted both domestic and overseas inventories,[46] (although large crops in 1966 and 1969 alleviated the condition, which is also reflected by the smaller forecast errors in these two years). According to economic theory represented in the model, this should have caused an even greater increase in the price of beans.

A possible explanation would be that demand for beans must have become extremely elastic. This would be due to the increasing importance of the export market (which is itself very elastic) and an increased elasticity of demand for beans on the domestic market, possibly due to beans being presented in a more attractive form to the consumer so as to become competitive with a greater range of products. It would therefore appear that the autoregressive scheme beginning in 1963 or 1964, seen in the forecast errors for the price equation, is largely explained by the factors which caused the change in the behavioral nature of the industry and those which caused the upswing in the rate at which disposable personal income increased.

---

[46] This is indicated in USDA, Vegetable Situation, reports covering these years.

One other relationship requires discussion. It was originally concluded that the specification of the relationship between government takeover and support price less "free-market" price[47] for navy beans for the years fitted was quite satisfactory.[48] Neither did there appear to be a problem with curvilinear relationship as seen in the burley tobacco auction model discussed in Chapter III. However, a problem does appear where large negative differences occur between the support and "free-market" prices, leading to the high overestimation of government takeover in years when there was little or no government takeover. This was a substantial factor in the large forecast errors in 1957, 1967, 1968 and 1970. It was also a lesser factor in the forecast errors for 1954, 1965 and 1969. It will be noted that these are all years of zero or very low government takeover. On this basis it seems largely a matter of good fortune that in the years for which the model was fitted there was significant government takeover in every year that the support program was in operation (1948-52) and the years prior to this that were fitted, in which there was this zero government takeover, the differences between assumed support price and estimated "free-market" price were small and tended to cancel each other out. Otherwise the coefficient for this relationship would have been considerably lower indicating a flattened and biased estimate of the relationship. Fitting the relationship without allowance for this problem in the years to 1970 would have resulted in this bias occurring.[49]

---

[47]See p. 102, footnote 31.

[48]Ibid., p. 50.

[49]See Vandenborre, op. cit., pp. 36-38 for a more comprehensive discussion of this problem and possible ways for reducing its influence.

Another possible disturbance in the relationship for the years 1957-70 is discussed in the next section.

B. Changes in Relationships not Included in the Model.--Probably the most important factor not included in the model is the effect of exports of pea beans, although it was explicitly recognized as being important. In fact, it was thought to be responsible for the residuals in the price equations in the years 1941, 1946, and 1947.[50] But the errors from not including this relationship in the model are likely to be more serious when it is used to make predictions of price and government takeover of dry beans in more recent years. This is because of the considerable increase in the importance of exports in the navy bean industry since the period for which it was fitted as is illustrated in Table 3.32. This shows that exports of navy beans increased on average in relation to production, from 13 per cent in the period 1949-56, to 20 per cent in the period 1957-68.[51] This was in spite of a 47 per cent increase in navy bean production between the two periods and represents an average increase of 129 per cent in exports.

---

[50] Dale E. Hathaway, op. cit., pp. 42 and 49. Exports could not be incorporated in the model because there was no breakdown of dry beans by classes prior to 1952.

[51] Some of this increase has been due to exports under PL 480, passed July 10, 1954. However the figures Vanderborre gave for navy bean exports under this act, (see Vanderborre, op. cit., Table 6, p. 11), show the amounts to be very irratic from year to year. Further in some years they were shown to be entirely inconsistent with total navy bean exports. (For a discussion see ibid., pp. 7-12).

TABLE 3.32.--THE INCREASING IMPORTANCE OF EXPORTS IN THE NAVY BEAN INDUSTRY IN MICHIGAN, 1949-1968

Item	1949-56[a] (thousands cwt.)	1957-68[b] (thousands cwt.)	Percentage Increase Between Periods
Average U.S. Exports of Navy Beans Annually	521	1,187	129
Average Total Annual Production of Navy Beans in the U.S.	4,054	5,946	47
Average U.S. Annual Exports as a Percentage of Average Annual Production	13	20	

[a]Data for years 1949 and 1950 are estimates (see Roger J. Vandenborre, *op. cit.*, Table 5, p. 10) and the years 1951 to 1956 are from Edward H. Krebs, *op. cit.*, Table II-2, p. 21.

[b]Data for years 1957-67 see *Ibid.*, and for the year 1968 was from U.S. Department of Agriculture, *Agricultural Statistics* (Washington, D.C.: Government Printing Office, 1970). No statistics were readily available for the years 1969 and 1970 at this time.

Although there is considerable confusion with the other factors discussed in the previous section,[52] it seems likely that it is partially responsible for the large underestimates of the price in the years 1958, 1959, 1962-64.[53] In each of these years exports represented 20 per cent or more of the total navy bean production.[54] It also seems likely that it contributes to the overestimation of government takeover of navy beans in those same years and 1965, the hypothesis being that the model does in fact indicate the amounts that would have been taken over by government had the greater portion of the amount represented in the forecast error not been removed to overseas markets.[53] In the remaining years, especially 1965-70, it is difficult to directly analyse the effects of exports because of complications with other factors already discussed.[55]

It may be possible that this situation is even more complicated than suggested above. The reason for this is based upon an examination of the behavior between government takeover and support prices less "free market" price of navy beans and a relationship estimated by Krebs. Krebs showed that for the years he was investigating 1951-67, in estimating domestic demand for navy beans, defined as U.S. production

---

[52] See pp. 112-116, A. Changes in Behavioral Relationships Included in the Model.

[53] If exports under PL 480 are subtracted from total exports and this amount then subtracted from the supply of pea beans and the forecasts from the model recalculated, takeover is underestimated but by a smaller margin than it was formerly overestimated. The forecasts for price are also more accurate. However, after 1965, allowing for exports increases the errors.

[54] See Edward H. Krebs, op. cit., Table II-2, p. 21.

[55] See especially pp. 113-115.

of navy beans, plus beginning inventory less U.S. exports and government takeover, that to obtain a good fit for his equations, it was necessary to include a "zero, one" variable to account for differences in domestic demand. From the period 1951-56 (i.e., zero variable) domestic demand increased by a constant of 696 thousand cwt. for the years 1957-67.[56] Although it was suggested that possible explanations for this behavior might be a change in the way data was reported or a change in taste occurring for the commodity, it was concluded there was no clear cut explanation for this phenomenon.[57]

When the relationship between takeover and support price less "free market" price was investigated for the periods 1948-56 and 1957-70, a discontinuity similar to that suggested by Krebs seemed to exist. A regression line was fitted to the data for this relationship in each of these periods though it was necessary to exclude the years 1957, 1960 and 1965-70 because of the difficulties with this relationship mentioned in the previous section[58] which would have seriously biased results.

The results indicated two regression lines with very similar slope coefficients and the difference between the intercept terms was

---

[56]Edward H. Krebs, op. cit., pp. 31, 38 and 42. It should be noted that the coefficient for the binary variable had a standard error of 1358. The domestic demand equation consists of four explanatory variables; an eight month average price for navy beans, and the price of small white beans (a competing crop) which are both assumed endogenous, and U.S. population, and the dummy or binary variable, which are exogenous. This equation is one of three structural equations which, together with an identity, represent the total demand structure.

[57]The latter explanation is unconvincing.

[58]See above p. 115.

762 in thousands of cwts.[59] Although no great reliance can be placed upon the coefficients in the second equation because of the number of observations that were excluded in estimating the relationship, it is considered that, overall, the difference between the two intercept terms is relevant information, which requires explanation. The size of the difference compares quite closely with the 696 coefficient for Kreb's binary variable. Again, the fact that the difference, 762, estimated above is larger than the discontinuity shown by Krebs may give added credulence to the estimate when it is considered that Kreb's relationship included a variable for exports in the simultaneous equation system, while that estimated above did not. The significantly greater exports in the second period, as seen in Table 3.32, would thus lead one to expect an overestimation of the difference in government takeover between the two periods since exports remove a significant portion of beans from the domestic market.

If these lower government takeovers hypothesized to exist since 1957 hold in fact, one possible explanation for this change might be that with the increase in U.S. exports of navy beans, the government no longer found it necessary to purchase large quantities of beans under the support program. This meant that through an active change in policy in about 1957 the government began to purchase some of its requirements for the school lunch program and other welfare and aid

---

[59]The equations fitted were for 1948-56: $Y_1 = 458 + 2.62X_1$ and for the period 1957-70: $Y_2 = -304 + 2.13X_2$ where Y_j = government takeover and X_j = support price for navy beans less the "free market" price of navy beans (see p. 102, footnote 31). $\hat{a}_1 - \hat{a}_2 = 762$.

commitments by directly competing on the commercial market.[60] These commercial dealings would account, it is suggested, for both a lower government takeover under the support program by definition, and an apparent increase in domestic demand as defined by Krebs.[61] However, this explanation is strictly hypothetical and needs further investigation to verify its existence. This is considered to be outside the domain of this thesis. In conclusion though, it would seem, if verified, to explain a significant proportion of the overestimates of government takeover by the equation for forecasted takeovers indicated by the large negative forecast errors in Figure 3.32 for 1958, 1959 and 1960-65.

Summary

The structure of the navy bean industry appears to have been reasonably stable during the period for which the model was fitted and possibly up until 1955 or 1956. The analysis above validates the specification of the model for this period. There are some reservations regarding the availability of data and the definition of when forecasts using the model would be made. In the latter case, the matter might well have been clarified if the main purpose of the model had been forecasting.

Since this time, however, the industry has become much more dynamic, and any econometric model which hoped to make accurate

---

[60]By the Agricultural Act of 1956, Sec. 205, authorization was given to the Secretary of Agriculture, beginning with the fiscal year ending June 30, 1957, to appropriate $500,000,000 to "Further carry out the provisions of Sec. 32 of PL 320, 74 Cong. as amended", (see USDA, ASCA, Compilation of Statutes, 1969, pp. 215-217).

[61]See above p. 118.

forecasts of prices and takeover based on variables reflecting the structure of the industry would have had to be modified a number of times. In fact as the analysis suggested above, by the 1960's, because of the number of changes that were involved, it was virtually impossible to indicate the individual effects of each using the model as a starting point. The implication of this, together with the lack of reliable data in the industry for exports and commercial carryover by classes, is that there is little prospect for making accurate predictions until these shortcomings are overcome. It may even be impracticable to obtain an accurate estimate of the new industry structure based purely on time-series data because of the number of changes involved.

CHAPTER IV

SUMMARY AND CONCLUSIONS

In Chapter I the background and objectives for this thesis and the method to be used in attaining these objectives was presented.

It was pointed out that in making present decisions, whether trivial or momentous, some unknown aspects of the future are usually involved. There is, therefore, a need to predict what these future aspects might be in order to improve the decision. For this purpose, econometric models, especially where they represent the structural relationships of the phenomenon of interest, can be most useful. Such models can provide the basis for making predictions which are verifiable, using a procedure which is also verifiable. These two properties enhance the usefulness of the model and its predictions.

A great volume of work has been done in the agricultural economics profession on the problems of specification and on procedures for estimating econometric models. Much of this has been concerned with the use of aggregate time-series data for analysing demand and supply relationships in agriculture. However, little effort has been made to evaluate these models explicitly, especially those based upon structural concepts, for their ability to forecast. This is in spite of a growing emphasis on this aspect in the econometrics profession which has developed and demonstrated methodologies and tools for this purpose.

The objective of this thesis was to demonstrate the use of some of the methodological concepts developed largely by the latter profession to make a preliminary evaluation of the econometric models based upon aggregate time-series data developed for two studies which were investigating production and price relationships for the burley tobacco and the Michigan dry beans industries. More specifically, the object was to determine whether the structural relationships specified in the models were valid and whether or not they might provide a useful basis for making predictions. This included a cursory examination to ascertain to what extent the predictions from the models might be useful in terms of their timeliness and accuracy. This can be determined if the predictions meet the conditions for verifiable forecasts. However, this thesis does not attempt to measure cardinally the accuracy of the forecasts made by the models.

The Structural Validity of the Models

The Evaluation Procedure

The method of analysis used was as follows. To evaluate whether the procedure is verifiable is equivalent to testing whether the theory and thus the structural specification of each model is sound. This was undertaken only on a preliminary basis. Final data were taken for all of the model's variables and then used in the model to make predictions for the dependent variable. These predicted values were subtracted from the actual values to give the forecast errors for the model. If the model was correctly specified and estimated, the forecast errors should be of the same general magnitude and distribution as the original residuals for the model. Where this is not the case either the model was incorrectly specified and/or estimated, or a change in the behavior of the section of the industry the model represents has occurred, or possibly both. To determine which was the case, on a preliminary qualitative basis, historical records were examined for evidence which would substantiate the nature of the departures indicated by the forecast errors for the model.

Where the model was shown to be correctly specified and estimated, it is a structurally valid model and can be extremely valuable to policy-makers and to decision-makers in general, for explaining the origin and nature of forecast values when no structural changes in a phenomenon's behavior have occurred. In addition, the model can be equally valuable when such changes do occur, for indicating when it happened and also for determining the size and possibly the nature of the change.

The Results

From the burley tobacco study, the underplantings model and the yield model were shown to have such properties.

The Burley Underplantings Model.--The underplantings model indicated a change in structural relationship that occurred around 1949 or 1950. It appeared that the nature of the new structural relationship could have been accurately assessed within 2 or 3 years of this time. Once this change was accounted for, the model accurately explained the origin of underplantings for the test period 1950-1970. In fact, its usefulness is highlighted in this instance by comparing the performance of the model with that of a naive model making forecasts of underplantings based upon the assumption of no change from the previous year. It would be doubtful whether the structural model could have made more accurate predictions than the naive model for this period, since there was very little change in underplantings, especially since 1960. But there were considerable changes in the values of the factors which determine underplantings. Thus the advantage of the structural model is that it explains why there was so little change in underplantings in these years in spite of changes in related factors.

The Burley Yield Model.--The yield model was useful in explaining the forces that determined the forecasts until 1961, especially when the influence of a factor, the size and distribution of allotments, which was noted as a source variation by the author but was not incorporated in the model, was allowed for. In fact, it was suggested in this thesis that the factor should be represented in the model, and that a variable for changes in the number of allotments from normal, might have represented this influence.

During the period prior to 1961 a change in the industry's behavior was indicated by the model which also showed that the effect of the change was a decrease in the annual variations in yield. This appeared to be substantiated by historical evidence. In 1961 the model immediately indicated a major change among the relationships determining yields of burley. This was traced to changes in the variable representing trend. It was noted though, that because this variable covered such a large number of factors, it would have been virtually impossible to determine accurately the magnitude of the increase in trend until possibly 5 or 6 years after it occurred. Luckily, as hindsight in 1970 reflects, there appears to have been only one change in the parameter for trend. It is also fortunate, as again determined from hindsight, that the high degree of multicollinearity that exists between the price, index of prices paid, and trend variables did not upset the model's ability to represent the industry's behavior. Nevertheless, it does detract from the confidence that a user can place in the explanatory power of the model for these variables.

The Dry Bean Yield Model.--The yield model for Michigan dry beans also demonstrated its ability to represent the behavioral relationships that are responsible for determining yield in that industry. When the inadequacy of the weather index to represent the full effect of weather on yields in certain years is allowed for, the model explains actual yields well until 1956. It then appears to show most successfully the effects over time of the introduction of a new upright variety of bean and the increase in fertilizer usage that accompanied it. Thus in the years that the new bean was being adopted by growers, apparently 1956-1959, the model could have provided a useful base, to which "guestimates" of the effects of the new variety could have been added, to predict yields in those years. Once the total impact was known this could have been easily incorporated into the model.

Useful structural properties could not be clearly demonstrated for any of the three remaining models analysed in this study, i.e. the burley tobacco auction model, and the acres planted, and price models for Michigan dry beans.

The Dry Beans Acres Planted Model.--Reliable data were not available with which to evaluate the structural properties of the acres planted model. All that could be concluded was that there were strong a priori grounds for believing that the original model would have had to have been modified several times since it was estimated to be still useful today.

The Dry Beans Price Model.--The model was claimed to be only partially structural by its author. This was considered to be ultimately responsible for the inconclusive results achieved from the analysis. The problem arose initially when, immediately after the model was estimated (as shown by Krebs), a change occurred in the hypothesized relationships represented by the non-structural variable for Great Northern beans. It was compounded by the high correlation between that variable and another explanatory. Later the problem was complicated still more by the number of changes that were speculated to have occurred in the industry's behavior during the years 1953-1970.

The Burley Auction Model.--The burley tobacco auction model as it stands is not a useful basis for determining the influence of the various factors which effect the price and pledges of burley tobacco from year to year. This is the result of a misspecification made in the model. Although the general effect of the bias was determined by the author, when the uncertainty generated by this factor was compounded by possible incorrect estimates of some of the coefficients of the explanatory variables, the total effect was to destroy the usefulness of the forecast errors for indicating the changes and the resulting new relationships which were speculated to have occurred in the industry.

The reason for suspecting the estimates for the parameters of some of the variables was "unlikely" behavior seen in the artificial data which were used for the support price in 5 of the 12 years used to estimate the model.

However, it was concluded that the relationships, specified in the model to represent the forces which determine "free-market" price, were structural and were correctly estimated. This permitted the effects of the support program since 1950 to be substantiated.

Data Limitations

The availability of data of adequate quantity and quality is required in addition to the use of recognised theoretical concepts to obtain a verifiable forecast procedure. Both limitations affected models in the two studies.

Quantity.--Limited numbers of observations available with which to fit the models manifested themselves in the form of an inability to incorporate additional explanatory variables, that were indicated by economics or other behavioral principles to be of some importance in explaining the behavior of the dependent variable, and/or in the form of insufficient observations left over with which to estimate the population variance. Leaving out variables involved in a relationship, or misspecification of the model, leads to biased estimates of the equation coefficients, and of the variance, unless the variable not included is uncorrelated with the other explanatory variables. Small numbers of observations left over, i.e. degrees of freedom, with which to estimate variance means that little reliance can be placed in the confidence limits, especially those for forecasts, and in particular where their validity is confined to large samples. It will be noted that reliable confidence intervals are necessary to obtain verifiable predictions as will be discussed below.

In all three burley tobacco models shortage of data were a problem. In the auction model it was necessary to use artificial data with the possible consequences that have already been noted above. In addition the estimation technique used for this model requires it to be based on a large sample for there to be confidence that the estimates derived from it have desirable statistical qualities. The problem was manifested in the underplantings and yield models as an inability to specify some less important relationships in the models. The consequences of these misspecifications do not appear to have been great. The analysis suggests that the most important omission was probably that no variable was specified to represent the effects of changes in the size and distribution of allotments in the yield model.

In the Michigan dry bean models omission of variables because of limited numbers of observations available was mentioned by their author for all three models. One which affected notably the performance of the price model in later years was the representation of real income and inflational effects with one variable,disposable personal income.

Quality.--Apart from the support price information used for the first 5 years for fitting the auction model, quality of data was not a significant problem in the burley models. It was, however, in the Michigan dry bean models and is recognised as such by the industry today.

No reliable estimates of commercial carryover by variety are available for dry beans. Export data were unreliable until just recently. These two deficiencies may have affected the fitting of the price equation, but they both affected the forecasting ability of the model in the 1950's and also the analysis of the model's structural validity attempted in this study. In the dry bean yield model the weather index was not reliable because it did not adequately represent the bean growing area in Michigan. It was reasoned that this problem and also the complete lack of data for the cost of production for corn, wheat and dry beans used in the acreage planted model were unlikely to be of consequence if these models were being used regularly for forecasting purposes.

The Timeliness and Accuracy of the Forecasts

The other portion of the analysis was to determine on a preliminary basis whether or not the predictions obtained from the models were verifiable.

The usefulness of a prediction, derived from a knowledge of the effects of the behavioral relationships determining it, is further increased if it is also equal or superior, in terms of timeliness and accuracy, to forecasts obtained by other methods.

Method of Analysis

To determine the usefulness of a prediction on these grounds requires that it be verifiable. This has been shown to depend on four conditions: 1) that it can be determined after a certain time that the forecast is either right or wrong; 2) that the concepts used are clearly defined; 3) that the time when the forecast would be made is clear; and 4) that there is a probability statement relating the predicted to the actual value, especially in the case of point estimates. The analysis undertaken on these aspects in this thesis was purely cursory. Nevertheless it does appear to have successfully uncovered features of the models in both studies which could be improved if their objective is forecasting.

The Results

If the USDA final estimates of the values for the various dependent variables is taken as being the actual figure, condition one was met for the models in both studies. The second condition regarding a clear definition of concepts was a problem in the acres planted model for dry beans where it was not completely clear which price of dry beans was being referred to (the same variable was also used in the yield model). Nor was it clear what concepts and individual items were used in arriving at the costs of producing dry beans, corn and wheat. The latter especially caused a problem in using the model. The quality index in the burley auction model had the same shortcomings.

In the case of dry beans the problem is due undoubtedly to the fact that the models were not intended to be used for more than the immediate study undertaken by their author. In the burley models it probably represents the fact that the models were presented to a general audience rather than to people who intended to use them immediately for the purpose of forecasting for which they were built.

For the same reasons the third condition was not met by any of the models. This means that the models as presented by their authors cannot be evaluated except on an ex post basis, i.e. only their structural accuracy can be determined. In particular, the analysis suggested that if the time when the forecasts would be made had been specifically considered in specifying the models, some of the variables might have been defined differently to improve the timeliness of the models' forecasts. In some instances it appeared that this might have even improved a model's structural accuracy. Specific examples were the two indices of prices paid in the burley underplantings and yield models and the previous year's price to farmers for dry beans in the acres planted and yield models for dry beans.

The fourth condition was generally met by all the models. However, only the yield model for dry beans appeared to have an unbiased estimator for variance. In all the other models some bias was indicated, although in the underplantings and yield models for burley this was of little consequence. In the underplantings model the statistical efficiency of the variance estimator meant that it was of little practical use.

Conclusions

First and foremost, where the analysis verified the initial structural validity of a model, this property was demonstrated to be most valuable in explaining the forecasts arrived at, and also in providing a sound basis for evaluating the effect of any structural changes that occurred in the industry.

As a corollary, the method of analysis was useful, at least on a preliminary basis, in indicating whether the models were structurally valid or not, although its ability was limited when a large number of structural changes overlapped one another in the test period. A more conclusive basis for analysis might be to fit the new relationships into the models and then to test the forecast errors using a U-statistic.

A still more rigorous and valid test of a model's structure would be to up-date it each year on an ex post basis before using the U-statistic to test the forecast errors. An evaluation of this nature represents the real world use of the model for forecasting where a forecaster, especially with the modern computational facilities available, would incorporate all the information at his disposal, i.e. the previous year's data, into the model.

Another conclusion from the analysis carried out in this thesis is that the usefulness of a structural model can be further enhanced by paying attention to when the forecasts will be made. Changes in the definition of certain variables in the model, which have little effect on its structural validity, may greatly affect how early the model can be used to make predictions. The earlier a forecast of a given accuracy can be made, the more useful the forecast. Final determination of the optimum timing of a forecast will depend on the specifications of the user, but he will require knowledge of the relationship of timeliness to accuracy for the model's forecasts in order to make his choice. This depends on the accuracy and availability of the data for the explanatory variables. An ex ante analysis using a U-statistic could be useful for plotting such relationships in future work.

The limited number of observations usually available in time-series often places restrictions on the number of relationships that can be specified in a model and/or the confidence which can be placed in the estimated relationships, when a model depends entirely on data from this source. Thus techniques which allow data from both time-series and cross-sectional sources to be incorporated in estimating models should increase the usefulness of econometric models for predictive purposes. Similarly, many data series are now estimated with greater frequency, which should also improve the performance of models for predictive purposes. Such models should be tested to evaluate how much these developments do improve the performance of the models.

A further development whose impact should be evaluated is the use of information in a Bayesian manner in econometric models which would seem to greatly increase the usefulness of statistical techniques for forecasting purposes.

Concluding Comments

From the conclusions above, it is obvious that there still exists a need for the development of improved econometric techniques to allow more efficient use of information. However their ultimate objective will in most cases be forecasting, and for this reason more emphasis should be placed on evaluating models for this purpose in the agricultural economics profession. This in turn should focus attention on the availability of appropriate data, since the accuracy with which the model both represents a phenomenon and later forecasts it depends in part upon the accuracy and adequacy of the data available.

Forecasting models derive their usefulness from their performance in terms of three criteria. These are their ability to represent or explain the structural relationships underlying the forecasts, the timeliness of their forecasts and the accuracy of their forecasts in comparison with other forecasts available. For a given phenomenon there will be various payoffs between these three criteria. What combination is used will depend upon what the forecast is being used for and when it is required. This can only be decided by the policy-maker or the decision-maker. But he will first require information on what the payoffs are between the three criteria. Thus the successful specification of a model and later its use depends upon a continuing communication between the user(s) of the forecasts, the researcher constructing the model and also experts with a sound knowledge of behavior of the phenomenon which is to be predicted. It should also be realised that, in their present state of development, econometric models in most circumstances are only one method, albeit a most useful one, of improving decision-makers' knowledge of the future.

SELECTED BIBLIOGRAPHY

Anderson, Axel L. Dry Bean Production in the Lake and North Eastern States. Agricultural Handbook No. 285, ARS, USDA, Washington, D.C.: U.S. Government Printing Office, 1965.

Bieri, Jurg and Schmitz, Andrew. "Time Series Modeling of Economic Phenomena", AJAE, Vol. 52, No. 5, December, 1970.

Fox, Karl A. Econometric Analysis for Public Policy. Ames, Iowa: Iowa State College Press, 1958.

________. Economic Models, Estimates and Risk Programing: Essays in Honor of Gerhard Tintner. Ed. Fox et al., Berlin, New York: Springer-Verlag, 1969.

Fuller, Wayne A. "Discussion", AJAE, Vol. 52, No. 5, December, 1970.

Haidacher, Richard C. "Some Suggestions for Developing New Models from Existing Models", AJAE, Vol. 52, No. 5, December, 1970.

Hathaway, Dale E. The Effects of the Price Support Program in the Dry Bean Industry in Michigan. East Lansing: Michigan State University Agricultural Experiment Station, Technical Bulletin 250, 1955.

Hayenga, Marvin L. Structure and Problems of the Navy Bean Marketing System. Report 91, Department of Agricultural Economics, Michigan State University, April, 1968.

Hedrick, Wilbur O. Marketing Michigan Beans. Special Bulletin 217, East Lansing: Michigan State College, Agricultural Experiment Station, November, 1931.

Jensen, Harold R., and Halter, Albert N. "Making of Decisions". A Study of Managerial Processes of Midwestern Farmers. Ames: Iowa State University Press, 1961.

Johnson, Glenn L. Burley Tobacco Control Programs. Bulletin 580, Kentucky Agricultural Experiment Station, 1952.

________. "Supply Function--Some Facts and Notions". Agricultural Adjustment Problems in a Growing Economy. Ames: Iowa State University Press, 1958.

________. "The State of Agricultural Supply Analysis". Proceedings Papers, Winter meetings, American Farm Economics Association, December 27-30, 1959. JFE, May, 1960, Vol. 42, No. 2.

Kmenta, Jan. Elements of Econometrics. New York: Macmillan Company, 1971.

Knight, Dale A. "Evaluation of Time Series on Data for Estimating Supply Parameters". Agricultural Supply Functions. Ames: Iowa State University Press, 1961.

Krebs, Edward H. "Simulated Price and Supply Control Programs for the Michigan Navy Bean Industry". Unpublished Ph.D. dissertation, Department of Agricultural Economics, Michigan State University, 1970.

Learn, Elmer W. and Cochrane, Willard W. "Regression Analysis of Supply Functions Undergoing Structural Change". Agricultural Supply Functions. Ames: Iowa State University Press, 1961.

Marschak, Jacob. "Economic Measurement for Policy and Prediction", Studies in Econometric Method. Ed. Hood, W. C. and Koopmans, T. C., Chapter I, New York: Wiley and Sons Inc., 1953.

Meyer, John R. and Glauber, Robert R. Investment Decisions, Economic Forecasting and Public Policy. Boston: Harvard University, Division of Research Graduate School of Business Administration, 1964.

Schmitz, Andrew and Watts, Donald G. "Forecasting Wheat Yields: An Application of Parametric Time Series Modeling", AJAE, Vol. 52, No. 2, May 1970.

Stekler, Herman O. Economic Forecasting. New York: Praeger Publishers, (London), 1970.

________. "Forecasting with Econometric Models: An Evaluation", Econometrics.

Theil, H. Economic Forecasts and Policy. Amsterdam: North Holland Publishing Co., 2nd edition, 1961.

________. Applied Economic Forecasting. Chicago: Rand McNally and and Co., 1966.

U.S. Department of Agriculture. Tobacco Situation. Economic Research Service, Washington, D.C.: U.S. Government Printing Office, various issues.

Vandenborre, Roger J. An Econometric Investigation of the Impact of Government Support Programs on the Production and Disappearance of Important Varieties of Dry Edible Beans. Research Report No. 294, Gionnini Foundation of Agricultural Economics, California Agricultural Experiment Station, December, 1967.

Wright, Karl T. The Economics of Bean Production in Michigan. Special Bulletin No. 270, East Lansing: Michigan State College, Farm Management Section, Agricultural Experiment Station, May, 1936.

Zarnowtiz, Victor. "An Appraisal of Short-term Economic Forecasts". Occasional Paper No. 104. New York: National Bureau of Economic Research, distributed by Columbia University Press, 1967.

Zellner, A. "Decision Rules for Economic Forecasting", Econometrics, 31.

SELECTED STATISTICAL SOURCES

Michigan Department of Agriculture. Michigan Agricultural Statistics. Lansing, various issues.

U.S. Department of Agriculture. Agricultural Statistics. Washington, D.C.: U.S. Government Printing Office, various issues.

________. Commodity Credit Corporation Charts. ASCS, Fiscal Division, Financial Analysis Branch, Washington, D.C., various issues.

________. Crop Production. Statistical Reporting Service, Crop Reporting Board, Washington, D.C.: U.S. Government Printing Office, various annual summaries.

________. Statistical Summary, Dry Edible Beans and Dry Field Peas. Cooperation publication, ASCS, ERS, FES., October, 1964.

________. Tobacco Market Review, (Light Air-Cured). Pt. 1, Type 31, Burley, Consumer and Marketing Service, Tobacco Division, Washington, D.C.: U.S. Government Printing Office, various issues.