ECONOMIC STRUCTURE IN AMERICAN AGRICULTURE

By

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The author bears all responsibility for the content of this thesis.

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AN ABSTRACT

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ABSTRACT

An economic structure of agriculture is described by considering the relationships which exist within and between twelve product categories. These product categories are:

1. Wheat	7. Eggs
2. Feed grains	8. Soybeans
3. Beef cattle and calves	9. Cotton
4. Dairy products	10. Flue cured and burley tobacco
5. Hogs	11. Fresh and processed vegetables
6. Poultry meats	12. Miscellaneous

The first eleven categories for which structural relations are developed include approximately eighty-five per cent of the value of farm production. The model describing these structural relations contains thirty-five functional equations plus several identities and involves approximately one hundred and ten variables. For each of the subsystems a complete structural model is developed which measures forces acting upon supply and demand. Single supply curves are developed for each category, but multiple demand curves covering commercial, government and inventory demands are considered where appropriate. Exports are considered to be exogenous to the model. The statistical estimation procedures involve both least squares (mainly for the supply curves on crops), and limited information maximum likelihood techniques. The observations used are for the 1929-53 period. Product categories two through seven including feed grains, beef, dairy, poultry meats and eggs, are fitted simultaneously in order to observe the interactions of

the feed-livestock complex. The remaining product categories are fitted as independent subsystems.

In general, the established relationships are significant with the supply relations showing more reliability than the demand equations. The method of dealing with price support operations involves functions which associate the amount of a commodity moving under loan with the difference between the support price and what the price would be in the absence of government operations. The effects of support operations are measured with varying degrees of success. The procedure works reasonably well for wheat, feed grain, and burley tobacco, but appears to be less applicable to the cotton, and flue cured tobacco categories.

The price and production estimates are aggregated into national indexes of prices received, physical production, and gross income. Model estimates of feed, seed, and livestock prices, in conjunction with observed prices for non-farm produced goods and services, are used in constructing an index of prices paid. Total production expenses for agriculture are estimated as a function of the prices paid index and the level of physical production. As a final aggregate measure, net farm income is computed as the difference between gross income and production expenses. The model is believed to be unique in view of its comprehensiveness, and because it may be used as an integral part of the Klein-Goldberger model of the national economy developed at the University of Michigan. The Klein-Goldberger model is used to generate estimates of per capita income, wage rates and the price level which are fed into the agricultural model. This represents an advantage over the usual demand analysis technique of considering these variables to be predetermined.

The validity of the model is tested by making predictions for 1954 and 1955, through formal statistical tests on the reliability of estimates and the realism of assumptions, and by checking for consistency between elasticities estimated using the model and independent estimates of a similar nature. The usefulness of the model remains to be tested and can only be judged by its ability as a basic device for forecasting values of important variables which compare reasonably well with subsequent observations.

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CHAPTER I

INTRODUCTION

The increasing emphasis placed upon econometrics in the past decade is the result of an increased desire for quantitative estimates which reflect the manner in which economic society operates. Economic theory in itself is a simplification of reality from which one can derive laws embodying regularities of behavior. Though this procedure presupposes the existence of stable laws, the problem of measurement still remains. The econometrician, not unlike the historian or sociologist, is concerned with social behavior and in particular with behavioral laws or relations. If one assumes that, in a certain society, behavior has been generated through a known stable process, it becomes possible to say something about future events. From this arises the goal of the econometrician--to construct quantitative estimates of economic relationships. He can select certain economic relationships which he believes will hold over time and proceed to measure them.

The purpose of this dissertation is to obtain quantitative estimates of the major macro relationships existing (1) within the agricultural economy of the United States and (2) between agriculture and the remainder of the economy. The approach used is to disaggregate agriculture into a series of product categories which have sufficiently homogeneous demand

and supply conditions and treat each category in detail. The selected categories are:

1. Wheat	7. Eggs
2. Feed grains	8. Soybeans
3. Beef cattle	9. Cotton
4. Dairy products	10. Tobacco
5. Hogs	11. Fresh and processed vegetables
6. Poultry meats	12. Miscellaneous

A more complete analysis of the disaggregating procedure is given in Chapter II.

For each product category, demand and supply relationships are specified and quantitatively estimated. Estimates of the physical quantities produced and the corresponding prices received by farmers are secured, the product of the two being a measure of farm income. Such income estimates are summed over all product categories to equal aggregate farm income.

In the estimating procedure, allowances are made for the interaction of product categories on each other by simultaneously estimating the parameters in the demand and supply functions of all related product categories. In addition the nonagricultural influences present are included by selecting relevant variables from a more complete "master" model[a] which has been developed previously.

The uniqueness and usefulness of this approach lies in (1) it's ability to treat each product category as an entity without restricting the interrelationships between categories and (2) in the aggregation of

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[a] L. R. Klein and A. S. Goldberger, An Econometric Model of the United States 1929-1953 (North Holland Publishing Co., Amsterdam, 1955) 165 pp.

the estimates for the product categories into indexes of prices received, prices paid, income and physical production for the agricultural economy. This does not mean that each category is treated in as much detail as commodity analysts might desire.

The resulting estimates are designed to show how agricultural income is generated, the interrelationships between product categories, and the way, in part, in which agriculture is affected by the remainder of the economy. As such, they form a basis for predicting future events.

However, at best, the econometrician can supply only a partial explanation of the manner in which people will react in the future. Omitted from any analysis are certain economic relationships, which individually may be insignificant, but which could be important as an aggregate. Another limitation is the existence of behavioral relationships generated by subjective uncertainty, and which, as a consequence, remain quite immeasurable. In addition, behavior may change in the future in a manner unknown at present which makes lengthy extrapolations dangerous.

The basic means for reducing the possible error in prediction, and conversely for increasing the probability of deriving correct and adequate estimates, is to incorporate plausible assumptions into the model and to use the best available data. Also, when the researcher has described rigorously, and completely, the actions of that portion of society to be studied and has obtained quantitative estimates, these estimates should be qualified through knowledge which cannot be incorporated as measureable variables. This means that results should be compared with independent studies of a similar nature for consistency and with the opinions and beliefs of those who have a close knowledge of the study area.

After one has selected a field of study and appropriate boundaries have been selected, the next major job is to make a theoretical specification of the existing economic relationships to represent the generating structure. This task is the most difficult one faced by the researcher. A complete description requires drawing upon economic theory, institutional information and technological knowledge. These are secured from observation, previous work in the area, introspection, and one's own beliefs and "feel" for the problem. Economic theory is never complete enough by itself to supply the needed foundations; caution along with ingenuity must be applied when specifying (1) the relevant variables which enter an economic relationship and (2) the functional form of such relationships.

In general, generating structures may be classified into four types of relationships:

(1) Those which describe the behavior or reaction of people. Entrepreneurial behavior is the process of supplying goods to the market and demanding the services of factors of production. The motive is that of profit maximization. Household behavior involves consumers' decisions in demanding goods and services while supplying labor. The motive is utility maximization.

(2) Those which describe technological relationships. Such relationships are commonly called production functions and involve the transformation of inputs into outputs.

(3) Those which describe institutional and legal arrangements. Examples of such restrictions are income tax rates, price support levels, or other alternative government payment programs.

(4) Those which are definitional or identities in a mathematical sense. The fact that the sum of gross individual incomes equals gross national income classifies it in this category.

Two sources of error arise in specifying and measuring empirical relations. The first is termed "shock" and is a result of omitting variables, while the second is "observational" which are errors of measurement in the observed data. Both of these errors are regarded as "random variables." The researcher must make an assumption regarding the probability of a joint occurrence of such errors, the nature of which is developed on pages 25 and 26. This assumption is an integral part of the estimating procedure. This assumption along with specification of the relevant variables in a relationship defines a structural equation. A group of interrelated structural equations can be referred to as a system of structural equations. If the form of each structural equation in a system is also specified, as for instance linear in the original variables, the set of structural equations is spoken of as a model.

Faced with different series of data, which supposedly measure the same variables, there is no unique way of estimating the parameters of the equations in a model. Thus, in the absence of a unique way, formulating a hypothetical model and observing the resulting estimates to see if they are realistic, followed by a reformulation, is an integral step in analysis. One of the reasons for distinguishing between behavioral and technological relationships lies in the relative importance of shock and observational errors in each. In technological relationships shock errors tend to be small relative to observational errors while the reverse situation generally holds for behavioral equations. Therefore, in reformulating equations it is likely to be more fruitful to investigate the data for those that are technological and to change the theoretical specification for those that are behavioral.

Just as there is no unique method of describing the existing relationships due to varied sources of data, there is also no unique way of carrying out the statistical analyses once the relationships have been specified and the data collected. Research in the field of statistical methodology constantly undergoes improvement. New methods are specified in great mathematical detail and arise to replace existing methods. In the past, the controversy over appropriate techniques has been a major issue in research analysis and it has often happened that few analyses have been made with the more advanced techniques; thus, comparisons with older, tried methods are often difficult to make. Such has been the case in the field of econometrics. Those people who advance the case for "model building" often do so on theoretical grounds with few actual empirical investigations being completed to yield comparative results. The older, better understood technique of applying a least squares regression equation in problem solving has thus remained in vogue.

The present study is not an attempt to enter into the controversy. The author operates, from the beginning, under the belief that relatively complete models have much more to offer on theoretical grounds than incomplete models; they enable the analyst to specify the important relationships for the problem to be studied and supply "best" estimates when appropriate statistical analyses are used. Thus, it would be difficult, if not incorrect, to make comparisons between methods on the basis of quantitative empirical estimates alone.

In the past, and to a lesser extent at the present time, models which consist of systems of equations involving a great many variables have been by-passed on the basis of their complexity. The simultaneous solution of systems of equations is a laborious job on desk calculators and may even prove to be quite complex on high speed electronic computers. However, problems of increasing complexity are being solved and the apparent limitations may soon rest in areas other than that of machine calculation. In particular, the limitations on availability, accuracy, and form of data are serious. Even though the econometrician familiarizes himself with all existing data in the problem area, he still may have to transform a theoretically correct model to an economic model capable of being solved in the light of existing data. In addition, new developments are needed in statistical theory which would define the restrictions which should be placed on estimates derived from small samples since, in most cases where annual time series data are used, the number of observations is limited. This study may be regarded as a testing ground for methodology but is not designed to improve upon existing statistical theory or methods of computation.

While, as stated above, the relationships to be specified and the statistical analyses to be used in solving this model are not unique, there is much to be gained by specifying the assumptions made at each stage of construction and solution. The reason for such specification lies in the desirability of considering any research project a link in a chain which may be improved by being broken and mended through reformulating and re-estimating. Research, or more precisely scientific investigation, is a continuous phenomena and the work of one person is seldom an entity in itself. Consequently one should design research problems in a manner which permits further study in particular areas. Attempts to "tie together loose ends" or present results as a "complete and independent package" may only result in making more difficult the continuation of a study. Consequently, as far as is feasible, a thorough specification of the methods of formulation, sources of data, and means of estimation are presented in the realization that numerous parts of this model may lend themselves to expansion through additional study.

In retrospect this project represents an expansion of one sector of the national aggregative "master" model produced by Klein and

Goldberger[a] and, at the same time, an aggregation of individual commodity studies into a more complete system for agriculture. Consequently the objectives are twofold in nature.

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[a] *Ibid.*

CHAPTER II

OBJECTIVES AND HYPOTHESES

Objectives

The first objective is to obtain estimates which would help farmers, policy makers, industry representatives and other persons interested in predicting demand and supply conditions for agricultural commodities. In the past, "economic outlook" reports for agriculture have concentrated on individual commodities or, at most, on a few related commodities neglecting interrelationships between commodities. This approach, tempered with individual judgment based upon a thorough knowledge of the area, has given useful results. However, a more elegant approach which ties together several interacting commodities is possible with known statistical techniques and currently available data. The latter approach, if not a substitute for the older method, may be considered a complement since it permits a comparison of results and an investigation of obvious inconsistencies. As outlook reports are designed for use in making farm adjustments, they must deal with individual commodities or closely related groups of commodities. Thus, it follows that the present study must disaggregate total agriculture to deal with commodities, or groups of commodities, which have partially, if not wholly, homogeneous demand and supply functions.

The second objective is to show, in structural detail, the influence of agriculture as an element in the total economy. Previous studies have attempted to integrate agriculture into a more general economic model. Foremost among these is the twenty equational econometric model constructed by Klein and Goldberger,[1] at the University of Michigan, which yielded quantitative estimates of national aggregative relationships. In the development of that model, it was reasoned that particular sectors, including the construction industry, foreign trade, agriculture and the money market, should be investigated intensively by specifying fairly completely the structural relations which exist in each of these sectors. The present study suggests a more elaborate method for deriving income and price estimates for agriculture. When such estimates are inserted into the Klein-Goldberger "master" model, the influence of agriculture on such macro-variables as gross income, saving, exports, price level, etc. may be estimated. By estimating the physical output from agriculture and the prices received by farmers for the commodities produced, one can compute gross farm income from farm production. If one adds to this, the other cash payments going to the farm sector, the sum will equal gross farm income. Deduction of farm expenditures leaves net farm income, a variable from agriculture of primary importance in the Klein-Goldberger master model. One definite advantage of linking the agricultural model to the master model is that the master model

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[1] L. R. Klein and A. S. Goldberger, An Econometric Model of the United States, 1929-1953, (North Holland Publishing Co., Amsterdam, 1955) 165 pp.

provides estimates of variables which are determined by forces acting upon the total economy and which affect agriculture. In particular, the master model provides estimates for disposable income, price levels, number of wage and salary earners and an index of hourly wages. These variables have a direct or indirect effect on the demand and supply of agricultural goods and services.

The two objectives outlined above are, for the most part, complementary. In addition to these objectives, intermediate objectives of a different nature could be set forth. For instance, though the testing and comparison of various statistical techniques, in itself, is an important goal, no attempt will be made to attain it except as necessary in gaining the basic objectives.

Hypotheses

A major hypothesis in this study is that the economic behavior of the agricultural sector of the economy can be described in a way that lends itself to quantitative measurement and subsequently to use it for predictive purposes.

In connection with this major hypothesis, certain beliefs are held and certain assumptions must be made. One subhypothesis is that processes of aggregation and disaggregation are necessary and can be performed in a manner which does not invalidate the results. The theory of consumer behavior and of the firm imply that certain aggregative relationships exist in the economic system. However, a measurement problem arises when one attempts to bridge the gap between individual behavior and group behavior. A satisfactory solution is obtained if aggregative index numbers can be constructed which are consistent with the two theories. Klein,[1] in two articles outlined the criteria that such indexes must satisfy to meet the consistency requirement under fairly restrictive assumptions.

Since this study does not emphasize improvement of current index numbers as an objective, an alternative approach will be used. Given that (1) economic relationships exist which express the behavior of firms and households, and (2) that data are currently published in a form which satisfy these relationships, then there exists a set of relations among the data which can be called a model of macro-economics. Data for the macro-system can be regarded as transformations of the variables appearing in the micro-economic equations.

Agriculture as a single sector must be disaggregated into commodity groups for which group models can be established. The decision on how to disaggregate agriculture into commodity groups is governed by three criteria. As stated above the first consideration is for results which would be useful for predicting supply and demand relationships for agriculture. Since people involved in "outlook programs" appear to desire estimating functions for each major agricultural commodity, this consideration favors detailed disaggregation.

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[1] L. R. Klein, "Macroeconomics and the Theory of Rational Behavior" and "Remarks on the Theory of Aggregation," Econometrica, Vol. 14, 1946.

The *second* criterion concerns the second objective and also the complexity of the problem. Assuming that a commodity breakdown is desired, a question arises as to the number of structural equations which can be handled by any accepted estimating procedure. Since the second objective is to determine the role of agriculture in the total economy, a product by product breakdown is unnecessary and relatively few equations may be needed. These two criteria must be considered and a compromise reached in view of available data, known techniques and knowledge of the economy being studied. The *third* criterion involves homogeneity of demand and supply functions. For instance, milk, cheese and butter might be aggregated into one category called dairy products, since the factors influencing supply and demand are to a large extent similar in nature. Conversely, the aggregation of soybeans, wheat, corn and other feed grains into one category may not be desirable since the conditions of supply and demand are quite different for some of these commodities.

After several revisions, which consisted mainly in further disaggregation from the original classification, the following twelve categories were selected. The first eleven categories included approximately 85 percent of the value of cash receipts from farm marketings and government payments in 1951, exclusive of payments made under the Sugar Act and for conservation practices. The final category is termed miscellaneous since many of the products cannot be grouped into categories where homogeneous demand and supply functions could be specified. The major products in this category are fruits and nuts, cottonseed, forest and greenhouse products and the sugar crops.

1. Wheat
2. Feed Grains
3. Beef Cattle and Calves
4. Dairy products (excluding meat)
5. Hogs
6. Eggs
7. Poultry Meats
8. Soybeans
9. Tobacco
10. Truck Crops
11. Cotton
12. Miscellaneous

CHAPTER III

REVIEW OF LITERATURE

It is not an easy task to specify the literature which should be studied prior to an investigation of this type. Certainly any previous study which uses similar techniques and covers a similar area is relevant. Other studies, regardless of subject matter, are relevant if they find solutions to problems of:

a) aggregation,
b) choice of time period,
c) choice of functional form,
d) selection and classification of variables,
e) use of complete versus partial systems, and
f) interpretation and significance of estimated coefficients.

The most prolific group investigating demand and supply relations for agricultural commodities are those people currently or lately employed by the Agricultural Marketing Service, United States Department of Agriculture. Foote, Klein and Clough[1] analyzed the economic forces affecting the demand for corn and total feed concentrates. Foote[2] supplemented this study with a four equational model of the feed-livestock economy using an iterative analysis. The econometric aspects of this

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[1] R. J. Foote, J. W. Klein, and M. Clough, The Demand and Price Structure for Corn and Total Feed Concentrates. United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., Tech. Bul. 1061, October, 1952.

[2] R. J. Foote, Statistical Analyses Relating to the Feed-Livestock Economy. United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., Tech. Bul. 1070, June, 1953.

model were also treated by Foote[3] by solving the equations using a least squares procedure and then transforming them into a set of difference equations to determine the type of oscillations that might result over time. Meinken[4] studied the demand factors for oats, barley and sorghum grains, again using least squares techniques. The price structure for wheat was explained in more detail by Meinken[5] in a six-equational model covering food, feed, export and storage demands. The system of equations was fitted simultaneously using the limited information approach. Rojko[6] in another model still linked to the feed-livestock economy constructed a three-equational model for the dairy industry solving the reduced-form equations by least squares techniques.

Armore[7] considered the relationships existing between the major edible fats and oils dealing with demands for domestic consumption, export and storage.

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[3] R. J. Foote, "A Four Equation Model of the Feed-Livestock Economy and its Endogenous Mechanism," Journal of Farm Economics. Vol. 35, February, 1953.

[4] K. W. Meinken, The Demand and Price Structure for Oats, Barley and Sorghum Grains. United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C. Tech. Bul. 1080, September, 1953.

[5] K. W. Meinken, The Demand and Price Structure for Wheat. United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., Tech. Bul. 1136, 1953.

[6] A. S. Rojko, "An Application of the Use of Economic Models to the Dairy Industry," Journal Farm Economics. Vol. 35, December, 1953.

[7] S. J. Armore, The Demand and Price Structure for Food Fats and Oils. United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., Tech. Bul. 1068, June, 1953.

Most of the above studies are closely related and represent part of the more general feed-livestock economy. Their objective was to gain quantitative estimates of the existing relationships. A study by Hildreth and Jarrett[8] in the same area elaborates on some of the problems met in model construction. The study is also an attempt to obtain useful empirical estimates but points out the possible gains to be made by the use of alternative structural equations, algebraic forms, selection of data, and testing of theories.

Literature of recent years discussing farmers supply response to price has been varied. Aggregative supply relations for agriculture have been described by Johnson,[9] Heady,[10] and Cochrane.[11]

A simple regression model of acreage and price was tried by Bowlen[12] in an attempt to measure Kansas' farmers' responsiveness to price. It showed limited usefulness with the response being due to the relative profitability of wheat over substitute crops, but the immeasurability of weather resulted in rather indeterminate results.

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[8] C. Hildreth, and F. G. Jarrett, A Statistical Study of Livestock Production and Marketing. Cowles Commission for Research in Economics, University of Chicago, Chicago, Illinois. Monograph 15. 1955.

[9] D. G. Johnson, "The Supply Function for Agricultural Products," American Economic Review, Vol. 40, September, 1950.

[10] E. O. Heady, "The Supply of U. S. Farm Products Under Conditions of Full Employment," American Economic Review, Papers and Proceedings Issue, May, 1955.

[11] W. W. Cochrane, "Conceptualizing the Supply Relation In Agriculture," Journal of Farm Economics. Vol. 37, Proceedings Issue, December, 1955.

[12] B. J. Bowlen, "The Wheat Supply Function," Journal of Farm Economics. Vol. 37, Proceedings Issue, December, 1955.

Walsh[13] tested the influence of cotton and cottonseed prices on cotton acreage for different time periods getting significant relationships.

Johnson[14] used a three-equation model to describe the effect of control programs on burley tobacco production and prices. This model was unique in the respect of measuring the impact of prices on both acreage "underplanted" and on burley yields. In addition, the price model incorporated the influence of support prices on the amount of tobacco placed under loan. The fitting procedure included only least squares techniques.

Similar econometric techniques were used by Hathaway[15] in developing a model for navy beans. Again a three-equation model covering acreage, yield and price was constructed being solved by limited information techniques.

Pubols and Klaman[16] measured farmer's acreage response to lagged potato prices and found significant relationships for the pre-war period.

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[13] R. M. Walsh, "Cotton Production In Response to Price," Journal of Farm Economics. Vol. 26, May, 1944.

[14] G. L. Johnson, Burley Tobacco Control Programs--Their Overall Effect on Production and Prices, 1933-50. Agricultural Experiment Station, University of Kentucky, Lexington. Bulletin 580. February, 1952.

[15] D. E. Hathaway, The Effects of the Price Support Program on the Dry Bean Industry in Michigan. Agricultural Experiment Station, Michigan State College, East Lansing. Tech. Bul. 250, April, 1955.

[16] B. H. Pubols, and S. B. Klaman, Farmers' Response to Price in the Production of Potatoes, 1922-41. Bureau of Agricultural Economics, United States Department of Agriculture, Washington, D. C., Mimeo. July, 1945.

A more recent study covering the effect of price support programs on potato production was undertaken by Gray, Sorenson and Cochrane.[17] The program in their opinion had the effect of redistributing the areas of production and increasing production by reducing risks.

Two studies which are valuable as areas for developing techniques as well as for empirical results were undertaken by Suits and his associates at the University of Michigan. The first study dealt with watermelons,[18] a commodity consumed almost entirely in fresh form and not capable of being stored. Suits showed a supply response to lagged watermelon prices and lagged prices for cotton.

The second study dealt with onions[19] which are primarily consumed in a fresh form and may be stored between crop harvests. The dynamics of this market followed a cobweb pattern with a supply response to lagged price being apparent.

Production responses to price have also been investigated by Kohls and Paarlberg[20] using single equation models. Halvorson[21] points out

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[17] R. W. Gray, V. L. Sorenson, and W. W. Cochrane, An Economic Analysis of the Impact of the Government Programs on the Potato Industry of the United States. Minnesota Agr. Exp. Station, University of Minnesota. Tech. Bul. 211, 1954.

[18] D. B. Suits, "An Econometric Model of the Watermelon Market," Journal of Farm Economics, Vol. 37, May, 1955.

[19] D. B. Suits, and S. Koizumi, "Dynamics of the Onion Market," Journal of Farm Economics, Vol. 38, May, 1956.

[20] R. L. Kohls, and D. Paarlberg, The Short-Time Response of Agricultural Production to Price and Other Factors. Agr. Exp. Sta., Purdue University, Lafayette, Indiana. Station Bulletin 555, October, 1950.

[21] H. W. Halvorson, "The Supply Elasticity for Milk in the Short Run," Journal of Farm Economics. Vol. 37, December, 1955.

that the low supply elasticity for milk is due to relatively few alternative opportunities, institutional arrangements which prevent exit and entrance into the industry, and the temporary income loss the producer faces when changing the pattern of freshening. In addition, in the short run producers are hesitant in decreasing the quality or quantity of feed fed when faced with a lower income due to decreased milk prices or in liquidating herds although the rate of culling may be varied as prices vary. Schuh[aa] developed cost curves for typical dairy farms in a specific region and aggregated these individual curves to estimate an industry cost curve. This represents a means of synthesizing a total supply curve and it, too, showed an inelastic response to price changes, although in many cases a decrease in prices paid accompanying a decrease in prices received resulted in no change in output. In a length of run where herd size and the productive capacity of cows could be changed an elastic supply response was observed.

The above literature represents some of the more recent efforts of research workers, with the importance of the individual studies being measured either as a contribution to methodology or as additions to the library of quantitative estimates. In addition to the literature dealing with the feed-livestock structure and supply responses, a great deal of time and effort has been expended investigating demand relationships. Fox[aa] analyzed the demand structure for a number of farm commodities

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[aa] G. E. Schuh, The Supply of Fluid Milk in the Detroit Milk Shed as Affected by Cost of Production. Agricultural Experiment Station, Michigan State University, East Lansing. Tech. Bul. (in process).

[aa] K. A. Fox, The Analysis of Demand for Farm Products. United States Department of Agriculture, Bureau of Agricultural Economics, Wasington, D. C. Tech. Bul. 1081, 1953.

under the assumption that supply was determined by forces acting prior to the time of current consumption. Using a series of demand-supply flow diagrams, Fox explained the rationale for his choice of single-equation methods. The fitted demand functions are then used in deriving price and income elasticities for the major farm commodities prior to World War II. This is probably the most comprehensive study completed in this area.

Several other research projects using econometric techniques of simultaneous equations have been completed. Judge[34] analyzed the economic structure for eggs looking at both supply and demand factors. The retail demand conditions for pork, beef, poultry and eggs were also investigated by Judge in conjunction with Nordin and Wahby.[35] Both simultaneous and single equation techniques were employed and comparisons were made, with the most reasonable results for eggs being obtained by using the latter technique.

Shuffett[36] investigated the demand structure for a series of vegetables. In most cases price was expressed as a function of per capita production, income and stocks in a single equation.

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[34] G. G. Judge, Econometric Analysis of the Demand and Supply Relationship for Eggs. Connecticut Agr. Exp. Sta., University of Connecticut, Storrs, Connecticut. Bul. 307, 1954.

[35] J. A. Nordin, G. G. Judge, and O. Wahby, Application of Econometric Procedures to the Demands for Agricultural Products. Agr. Exp. Sta., Iowa State College, Ames, Iowa. Res. Bul. 410, July, 1954.

[36] D. M. Shuffett, The Demand and Price Structure for Selected Vegetables. United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., Tech. Bul. 1105, December, 1954.

Goris[27] outlined the conceptual framework of the American tobacco market and computed quantitative estimates using multiple regression methods. Her framework specified prices as being determined by supply, industrial production and consumption habits as measured by the trend in disappearance.

Shuffett and Rudd[28] studied the demand interrelationships between different types of tobacco at the auction market level also using a multiple regression approach. Price was expressed as a function of per capita production, stocks, and income. Exports, quality factors and rate of disappearance were qualitatively discussed in the analysis. An intensive study of the factors influencing the demand for meat was completed by Working[29] using both single-equation and simultaneous equations techniques. Long run and short run elasticities of demand were computed with the former shown to be more elastic than are short run demands. Working also inserted the general price level as a factor determining prices in the hope of separating price and income effects in the demand function. The study is an example of the different techniques and alternative functions which may be used with good justification in a demand relationship.

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[27] H. Goris, An Investigation Into Some Price-Determining Factors In American Tobacco Markets. North Holland Publishing Company, Amsterdam, 1954. Pp. 109.

[28] D. M. Shuffett, and R. W. Rudd, Demand Interrelationships Among Domestic Cigarette Tobaccos. Kentucky Ag. Exp. Sta., University of Kentucky, Lexington, Kentucky, Bul. 633, June, 1955.

[29] E. J. Working, Demand For Meat, Institute of Meat Packing, University of Chicago, Chicago, Illinois, 1954, 135 pp.

The above list is not complete in any sense. However, it does point out the areas where demand and supply investigations have been conducted, the alternative statistical techniques available, the criteria used for deciding upon functional forms, type of model, and provides a background of studies against which the present one can be tested for consistency. In other words, they have been selected from the standpoint of their contribution to both methodology and empirical results. The literature covering actual procedures used in estimating relationships will be discussed in the following chapter.

CHAPTER IV

ESTIMATING PROCEDURES

While this study does not develop statistical techniques, it seems advisable to present a very condensed version of the methods of estimation used in the analysis. A more detailed explanation may be found in the several sources[1] studied.

In the specification of each structural equation within the model those systematic and observable variables are included which explain how the endogenous variables fluctuate over time. Exact relations of this type are impossible to specify except for identities. For the other non-identical relationships the unexplainable part is included as a random disturbance u_{it}. The exogenous variables in each structural equation are assumed to be independent of the u_{it}, as well as unaffected by the endogenous variables. Since in most cases where subsystems are

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[1]The principle sources of estimating procedures are:

a) Cowles Commission for Research in Economics. Studies in Econometric Method, edited by T. C. Koopmans and W. C. Hood. (John Wiley and Sons, New York, 1953.)
b) L. R. Klein, A Textbook of Econometrics. (Row Peterson and Company, Evanston, Illinois, 1953.)
c) L. R. Klein and A. S. Goldberger, An Econometric Model of the United States, 1929-52. (North Holland Publishing Company, Amsterdam, 1955.) The computational design was taken mainly from the handbook of Friedman and Foote.
d) J. Friedman and R. J. Foote, Computational Methods for Handling Systems of Simultaneous Equations. Agricultural Marketing Services, United States Department of Agriculture. Washington, D. C. Agriculture Handbook No. 94, November, 1955.

considered there is some arbitrariness in specifying whether a variable is purely exogenous or could also be classified as endogenous by considering a larger system, this assumption is not always strictly satisfied. In addition the distributions of the u_{it} are assumed to be the same for all time periods with the disturbances in one time period being independent of those in any other period.[a] The u_{it} are random in the sense that a certain probability can be attached to each size of unexplained error. One should attempt to use a priori knowledge in specifying the nature of these random variables but for reasons of simplicity and lack of more complete knowledge, such distributions are usually assumed to be normal with zero means and a finite, unknown covariance matrix.

This assumption is characteristic of the model under study. Hence, the reader must realize that predictions of the values of the endogenous variables cannot be exact but are probabilistic. The reasons for this are that (1) sampling errors are present because of the small size of the samples and (2) "shocks" or disturbances occur because the estimated system does not completely describe the manner in which the true system is generated. This happens because of the omission of variables relevant to the system.

The problem of estimation involves considering the structural equations as a system where the u_{it} are functions of the endogenous

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[a]This assumption is used for simplification in the estimating procedure and may be relaxed under certain conditions. See H. Chernoff and H. Rubin, "Asymptotic Properties of Limited Information Estimates Under Generalized Conditions," Chapter VII, of Studies In Econometric Method, op. cit.

variables for given values of the predetermined variables. Knowing the distribution of the u_{it}, one can derive a conditional distribution for the endogenous variables. The probability density of this conditional distribution can be maximized by choosing certain "maximum likelihood" estimates for all of the structural parameters.

A modified version of this method is used which does not involve the use of all structural parameters in the estimating process. This is known as the limited information approach. The essence of this approach is that (1) it involves estimating one structural equation at a time; (2) it ignores restrictions on all other equations other than the one being estimated, i.e., it makes no specification regarding the variables entering any other specific equation and what their influence would be, but merely asserts that other variables are present in the system, and (3) it assumes that each endogenous variable can be expressed in reduced form. This approach ignores some information in the system, namely the explicit existence of endogenous variables in the system other than in the equation being estimated. Resort is made to the limited information single equation (LISE) method since application of the full information method prescribes specifying a complete model which becomes very complex and very expensive to estimate. The LISE estimates are consistent but may be less efficient in a statistical sense, since some information has been ignored. However, the simultaneity of the system has been recognized and serves to prevent the introduction of bias into the estimates.

In order to obtain unique estimates of the parameters of each structural equation it is necessary that the equation be identifiable. A necessary condition for identifiability of an equation is that the number of variables in the system exclusive of those appearing in the equation being estimated be at least as great as the number of endogenous variables in the system less one; if exactly as great the equation is just identified, and if greater the equation is overidentified. In the following subsystems all equations fitted by the limited information method are overidentified.

There are shortcomings to the limited information approach which may make it necessary to deal with subsystems within the model. In the fitting process for each equation, a regression of each endogenous variable on all predetermined variables in the system is computed. If the number of predetermined variables is greater than the number of observations the results are indeterminate. Hence, for small samples, it may be necessary to deal with a subsystem which excludes some predetermined variables.[a] Such has been the case in the model for agriculture. However, the subsystems dealt with are fairly complete models by themselves and the omission of predetermined variables from any one of them is not judged to cause a serious loss of efficiency.

In particular, the feed-livestock model is fitted as a subsystem. This includes the categories of feed grains, beef cattle, hogs, dairy products, eggs and poultry meats. Some omitted variables which may

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[a]For a more detailed description of the criteria for omitting predetermined variables see the article by H. Chernoff and H. Rubin, *ibid*.

influence this subsystem are wheat, soybean meal, and cottonseed oil meal used as feeds. The remaining categories are fitted as independent subsystems. This estimating procedure necessitates an aggregation of income and "prices received" by subsectors in order to arrive at desired income and price estimates for agriculture as a total. By observing the manner in which the structure is generated one can make a priori conclusions as to how much an aggregation should be done.

The Klein-Goldberger master model deals with the 1929-53 time period, omitting the war years, and is based upon calendar year observations. A 1929-53 period is also used in the agricultural model with the war years included. Production and marketing decisions on the farm are fairly repetitive annually; thus, aside from the data being more readily available in annual form there are fairly good institutional and biological reasons for selecting annual time periods. However, within the use of annual time periods the decision was made to use a combination of crop years for all crops and calendar years for all other categories. These differences of choice are rationalized in the feed-livestock categories by assuming that feed as an input in livestock production has a three month lag attached to it.

All equations in this model are linear in the original variables. This may be a rather arbitrary restriction and it is entirely possible that more appropriate functional forms could be found for certain equations.

Examination of each of the twelve categories reveals a similarity of behavioral relationships. In general, they may be described as follows. Farm production involves the transformation of inputs into outputs to be marketed. The marketing process may take several forms. The product may be sold into non-farm channels, remain in storage on the farm and become an input at a later stage or it may be sold directly to other farm producers as an input in another category. If commercial sales are made, the product may be consumed in a fresh form, processed for later consumption or stored if nonperishable. Since sales are seldom made directly to consumers, the price received by the producer is influenced by the actions of the intervening, wholesaling, processing, transporting and retailing agencies. The government may enter the market either on the supply or demand side. Exports and imports of particular commodities may also occur. A general identity showing the sources of distribution during a given time period may be specified as follows:

$$Y_{i1} + Z_{i6} = Y_{i3} + Y_{i4} + Y_{i5} + Y_{i6} \tag{4.1}$$

Y_{i1} = production, in physical units of the i^{th} category

Y_{i3} = net exports

Y_{i4} = government demand, or amount of production going into government storage.

Y_{i5} = commercial demand including products consumed in the farm household.

Y_{i6} = inventory demand, or the amount of farm storage

Z_{i6} = beginning inventory

Y_{i2} = price per unit of product

Y symbols designate those variables which are determined by forces operating within the agricultural sector of the economy and are termed endogenous. Z variables are called predetermined; they are determined by forces outside of the agricultural sector or they may consist of endogenous variables for a previous time period. The first subscript refers to the category being considered while the second refers to the variable within the category.

The endogenous variables in (4.1) can be transformed into value terms by multiplying each by its appropriate price. Summing over the i's would then give the value of gross cash receipts from farm production, R, as given in identity (4.2).

$$(4.2) \qquad R = \sum_{i=1}^{12} \left(X_{i8} \; [\, X_{i2} + X_{i6} + X_{i9} \,] \; + X_{i4} \cdot X_{i8}'\right)$$

The products going into commercial, export and farm inventory channels are valued at the prevailing market price X_{i8}, while those entering government hands are valued at the current support price X_{i8}'. To R could be added G, the government payments going to farmers exclusive of commodity price support operations to get gross farm income.

Since one of the objectives is to estimate net farm income the value of farm expenditures must be deducted from R + G. Farm expenditures E are the costs of items purchased for use in production such as machinery and equipment depreciation, livestock, feed, nonfamily labor, and a category of expenses including cash outlays for fertilizer, herbicides, insecticides, gas, oil, repairs, taxes, etc. Suppose that n such expenditures exist and that a_i measures the proportion of each such expenditure used in each of the twelve categories.

Then $\sum_{t=1}^{n} X_t \cdot c_{it} (i = 1,2 \ldots.12), (t = 1,2,\ldots.n)$ represents the physical quantity of inputs allocated to the i^{th} category. If these are valued at prices P_{it} the value of cash expenditures for the i^{th} category may be represented by (4.3).

$$(4.3) \quad \sum_{t=1}^{n} (X_t \cdot c_{it}) P_{it}$$

If input prices are the same among categories the i subscript can be dropped from P_{it}.

For all categories the aggregate value of production expenditures may be summed as in (4.4).

$$(4.4) \quad \sum_{i=1}^{12} \sum_{t=1}^{n} (X_t \cdot c_{it}) P_{it}$$

N, the value of net farm income, is derived in (4.5).

$$(4.5) \quad N = R + G - \sum_{i=1}^{12} \sum_{t=1}^{n} (X_t \cdot c_{it}) P_{it}$$

Also included as one of the objectives is the estimation of an index of prices received by farmers, P_r. If the Y_{ia} are weighted by quantities sold per category during a given base period, an index may be produced for year t as represented in (4.6). In this equation q_{io} and Y_{ia_o} are respectively the quantities sold and prices received for category i during the base period o, and Y_{ia_t} is the current price received for the i^{th} commodity.

$$(4.6) \quad P_{rt} = \frac{(Y_{ia})_t}{(Y_{ia})_t} \; \frac{q_{io}}{q_{io}}$$

From identities (4.1) and (4.2) six endogenous variables can be distinguished. These are for each product category: production, commercial demand, government demand, inventory demand, export demand and price received. These then are the variables considered initially in constructing the theoretical model for each category. Each was examined by considering forms which could be adapted to individual categories.

CHAPTER V

FEED GRAINS AND LIVESTOCK

Oats, barley, corn and sorghum grain represented 86 percent of the total supply of feed concentrates fed in 1950, byproduct feeds accounted for 12 percent and wheat made up the remaining two percent. The choice of these first four grains as the components of the feed grains catetory is made on the basis of their importance as shown above and their homogeneity in production and use. Foote[1] writes that "year to year changes in yields of feed grains other than corn are associated with changes in yields of corn. This would be expected as the heavy-producing areas coincide to a considerable extent, and as weather is a common factor." Cultural practices are quite similar for the production of these four crops as much of the machinery, land, and labor is substitutable between crops.

Supply Relationship

Feed grains are treated on a crop year basis. That is, the supply available for marketing in any one crop year consists of the October 1st carry-over of old corn not in government hands plus the new crop, the

[1] R. J. Foote, J. W. Klein, and M. Clough, The Demand and Price Structure for Corn and Total Feed Concentrates, United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., Tech. Bul. 1061, October, 1952, 8 pp.

July 1st carry-over of barley (August 1st from 1929-33) plus current production, the July 1st carry-over of oats plus current production, and the October carry-over of sorghum grains plus current production. To this total is added the net imports for each of the four crops. Another possible source of supply is the release of grain from government stocks. However, this analysis is not of sufficient scope to trace, in an accounting manner, the release of stocks from Commodity Credit Corporation inventory for subsequent use as domestic feed grains. A quantitative analysis of this type would be very difficult since the legal restrictions concerning release may be changed within a crop year, and in addition stocks may be released to meet current exigencies. These represent structural changes of a violent nature and can best be dealt with in subsequent prediction work on a qualitative basis. The resultant supply variable then represents the amount of feed grains which can be channelled into the various domestic uses, and is fixed for the current year. In describing the supply relations for feed grains a decision was made to use a behavioral rather than a technological function.

A production function is generally regarded as a technological relationship describing how certain inputs may be transformed into outputs. When looking at each product category, specific inputs must be measured if the production function approach is to be used. This means that α_{it} must be known, i.e., how each input is allocated to its respective use. At the present time, data on such a distribution of inputs are not available at an aggregative level.

Some estimates[*] have been made for the year 1947 and at the present time a project is underway within the United States Department of Agriculture to gain further data.

In addition to this limitation of the production function approach, additional problems are encountered when one attempts to specify technical production functions rather than behavioral relations. Although the production function for the firm may be known, there is a major gap in aggregating such individual functions into a macro-production function. The problem is mainly one of securing data in aggregative index forms which permit the transformation of variables in the micro-function to those appearing in a macro-function. If this could be done there would be advantages in fitting technical production functions. The main two are that fitting such functions does not depend upon profit maximization, and given a change in the marginal productivity of one or more inputs such functions make it possible to estimate the forthcoming change in production. One additional comment is that while we can be successful in at least a limited sense in specifying production functions there is no measureable counterpart on the demand side of the economy. The immeasurability of interpersonally comparable, absolute, utilities by necessity reduces the specification to one of a behavioral demand function. The obvious alternative is to use behavioral supply functions which assume the existance of technological functions but eliminate them

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[*] K. A. Fox, and H. C. Norcross, "Agriculture and the General Economy," <u>Agricultural Economics Research</u>, United States Department of Agriculture, Bureau Agricultural Economics, Washington, D. C., Vol. IV, January, 1952.

as an explicit part of the structure by going to a reduced form. For feed grains in particular, the reduced form is derived from structural relations numbers (5.1) and (5.2) below.

(5.1) $(Y_{81}, Y_{86}/Z_{81}, Z_{84}, Z_{87}, Z_{88}\ u_{81})$

Y_{81} = production of feed grains in hundred thousand tons

Y_{86} = hundred thousands of acres planted

Z_{81} = time, with year 1929=0

Z_{84} = an index of the number of tractors and combines on farms

Z_{87} = thousand tons of fertilizer applied in the North Central States

Z_{88} = unharvested acreage of feed grains during the current year

u_{81} = random disturbance

The diagonal bar separates the variables with those being designated as endogenous on the left and those considered as predetermined on the right.

The production function given in (5.1) states that production is associated with the acreage planted and those factors which affect the yield on this acreage. The time factor involves a linear trend in production due to many factors such as varietal improvements, weed control etc., which may be small individually but important as an aggregate. The amount of mechanization influences production since it enables planting, cultivation and harvesting to be undertaken at the most appropriate times. Fertilizer applications are assumed to have a positive effect on production. No satisfactory breakdown of fertilizer application on farms growing feed grains is available; hence, fertilizer application for the main region producing feed grains is used as a substitute measure. The unharvested acreage variable is included in an attempt to remove some of the influence of weather on production. This represents an implicit assumption that unharvested acreage is inversely correlated with the climatic conditions necessary for high production.

Since acreage appears endogenously, an additional equation was added. As this equation contains only one endogenous variable, unbiased parameter estimates may be obtained through a least squares procedure.

$$(5.2) \qquad Y_{26} = f\left(\left[\frac{Y_{22}}{Y_{12}}\right]_{-1} Z_{23},\ u_{26} \right)$$

Y_{26} = hundred thousand acres planted to feed grains

$\left[\frac{Y_{22}}{Y_{12}}\right]_{-1}$ = relative prices of feed grains and wheat for the previous year

Z_{23} = yield of feed grains per acre for the previous year

u_{26} = random variable

This relation treats wheat as the closest competitor for the inputs used in feed grain production with acreage shifts between the two categories being mainly determined by their relative prices during the preceding year. Yields of feed grains in the previous year are also included since there may be an inducement to increase the acreage planted when past yields have been above average and to decrease it when past yields have been unfavorable.

Equations (5.1) and (5.2) may be written in more complete theoretical form and reduced algebraically. As the parameters a_{ij} are all positive, one can inspect (5.3) to see if changes in sign have occurred in going to the reduced form. In all cases the structural equations are linear in the observed variables.

$$(5.1)' \quad Y_{s1} = a_{11} Y_{s6} + a_{12} Z_{e1} + a_{13} Z_{s4} + a_{14} Z_{s7} - a_{15} Z_{s3} + a_{16} u_{s1}$$

$$(5.2)' \quad Y_{s6} = a_{21} \left[\frac{Y_{s2}}{Y_{12}}\right]_{-1} + a_{22} Z_{s2} + a_{23} u_{s6}$$

Substituting (5.2)' into (5.1)' results in the final production relation (5.3).

$$(5.3) \quad Y_{s1} = a_{11} a_{21} \left[\frac{Y_{s2}}{Y_{12}}\right]_{-1} + a_{11} a_{22} Z_{s2} + a_{11} a_{23} u_{s6} + a_{12} Z_{e1} + a_{13} Z_{s4} + a_{14} Z_{s7} - a_{15} Z_{s3} + a_{16} i_{s1}$$

The random disturbances may be combined to give a new random variable. It is apparent that going to the reduced form does not involve a change in the sign of any parameter.

The computed least squares regression of (5.3) gave the following results for the years 1929-53. The standard error of each regression coefficient appears below it in parentheses.

$$(5.4) \quad Y_{s1} = 644.342 + \underset{(9.19)}{16.984}Z_{e1} + .00936Z_{s2} + \underset{(3.588)}{3.860}Z_{s4} + \ldots - \underset{(.392)}{1.423}Z_{s3} - \underset{(.065)}{.105}Z_{s7}$$

$$\underset{(.244)}{.362} \left[\frac{Y_{s2}}{Y_{12}}\right]_{-1} - \underset{(.392)}{1.423}Z_{s3} - \underset{(.065)}{.105}Z_{s7}$$

$$\bar{R}^2 = .84$$

The parameter for fertilizer has a sign opposite to that hypothesized. One explanation appears to be that while fertilizer application per acre has been increasing through time the effect on production is more than offset by a decrease in the acreage of feed grains with soybeans taking some of the better land out of production.

Demand Relationships

The utilization of feed grains can be separated into three main components.

1) Grain used commercially for livestock feed and industrial processing.

2) An inventory demand, which includes farm storage of grains not under loan or purchase agreement.

3) Government demand which includes that grain placed under loan and not redeemed plus the purchase agreement grain delivered to the Commodity Credit Corporation.

While it would be possible to separate the amount used for livestock feed from industrial processing, the two are treated as one category. The demand factors influencing this category represent those influencing only the grain used as livestock feed.

These four feed grains are assumed to be readily substitutable in use as livestock feeds and, hence, are combined into one category. Jennings[a] has estimated the feed-unit value of each of these grains for all types of livestock and concluded that 100 pounds of barley equals

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[a] R. D. Jennings, Consumption of Feed by Livestock, 1909-47, Relation Between Feed, Livestock and Food at the National Level. United States Department of Agriculture, Circ. 836, 105 pp. illus. 1949.

95 pounds of corn, 100 pounds of oats equals 90 pounds of corn, and 100 pounds of sorghum grain equals 100 pounds of corn. Meinken[4] states that "the same variables that would explain variations in either the index of feed-grain prices or prices of corn also would explain most of the variation in the prices of oats, barley, and sorghum grains." Thus there is good justification for treating those four grains as one commodity.

Given the level of feed grain supplies for one year, estimates are needed of the amounts of grain allocated to each of the three component uses. In addition policy makers and others need estimates of the resultant market price when the government influences the market. These estimates are secured in two stages. The first stage treats the feed grain-livestock complex assuming that government forces are not acting in the market. The second stage deals with the government demand for given livestock prices and support level for corn.

The following system of relationships and identities is specified for the feed grain-livestock economy:

(5.5) $Z_{21} = Y_{21_{-1}} + Y_{20_{-1}} - Z_{24}$

(5.6) $Z_{21} = Y_{23} + Y_{24} + Y_{25}$

(5.7) $(Y_{23}, Y_{22}, Y_{26}, Y_{32}, Y_{42}, Y_{52} / Z_{26}, u_{23})$

(5.8) $(Y_{25}, Y_{28} / Z_{21}\ u_{25})$

(5.9) $(Y_{24}, [Z_{26} - Y_{28}^{*}], u_{24})$

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[4]K. W. Meinken, The Demand and Price Structure for Oats, Barley and Sorghum Grains, United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., Tech. Bul. 1080, September, 1953, 17 pp.

Y_{21} = current production of feed grains in hundred thousand tons.

Y_{22} = price index for feed grains, 1910-14=100.

Y_{23} = tens of thousand tons of feed grains used commercially.

Y_{24} = tens of thousand tons of feed grains placed under loan or purchase agreement.

Y_{25} = tens of thousand tons of feed grains placed in storage on farms and not under loan or purchase agreement.

Y_{22}^{*}= "free" market price for feed grains 1910-14=100.

Y_{32} = price of beef in cents per hundred pounds.

Y_{42} = price of milk in cents per hundredweight.

Y_{52} = price of hogs in cents per hundred pounds.

Z_{21} = supply of feed grains available for utilization in hundred thousand tons.

Z_{23} = hundred thousand animal units fed during the year beginning October 1st previous.

Z_{24} = national average support price for corn, 1910-14=100.

Z_{25} = net exports of feed grains in tens of thousand tons.

u_{23}, u_{24}, u_{25} = random variables.

The first two relationships are definitional, the first showing the manner in which supply is aggregated, and the second the manner in which the supply is utilized. As identities they do not include random errors (if errors of observation may be assumed to be negligible). Identity (5.5) states that the supply available for use is equal to current production plus the carry-over of feed grains minus net exports. Net exports are included in order to make the first relationship a true identity and not because of their importance as a determinant of price.

Identity (5.6) equates the available supply and the three major uses. The amount of feed grains used commercially is a residual item being computed from the equation

$$(5.10) \qquad Y_{22} = Z_{21} - Y_{24} - Y_{25}$$

and thus includes all errors due to minor uses not specified in (5.6).

Commercial Demand

If Y_{24} equals zero in identity (5.6), relationships (5.7) and (5.8) are sufficient to explain the use of feed grains and the resulting market price. The commercial demand for feed grains is associated with the price of grain, the prices of grain consuming livestock and the number of livestock to be fed during the year. Given the number of animals on farms at the beginning of a time period, the profit maximizing principle states that the rate of feed consumption will increase until the ratio of the price of livestock products to that of grain equals the ratio of the marginal value product of grain in producing livestock products to the price of grain. This represents the change in feed consumption and livestock production which can occur in a time period where the numbers of livestock fed are stable. Increases in numbers fed occur most readily in the "hog" category since multiple farrowing may occur in any one year. To account for spring farrowed pigs (which would be farrowed during the year and thus make Z_{25} endogenous) an independent estimate of the number of animal units fed during the year will be made. This does not imply that more suitable alternatives could not be found. A more complex structure could include only the beginning inventory of livestock as being predetermined and treat endogenously the change in the number of animal units fed during the year. The final factor influencing the commercial demand is the amount of feed grains being carried over in storage but not under government loan. If all other factors remain constant an increase in inventory demand will be associated with a decrease in the demand for feed or industry.

The limited information single equation estimates (to be referred to as LISE) for this relationship appeared to give unreasonable residuals and it was discarded in favor of the least squares fit given in (5.11).

$$(5.11) \quad Y_{22} = -3119 - \underset{(.815)}{.900Y_{25}} - \underset{(.643)}{.124Y_{25}} + \underset{(.796)}{1.133Y_{52}} + \underset{(1.160)}{7.904Z_{25}} + \underset{(.570)}{.271Y_{52}}$$

<u>Inventory Demand</u>

In quantity terms, the carry-over of feed grains not under government programs is small and fluctuates very little. However, in percentage terms, these fluctuations are pronounced and justify the inclusion of (5.8) as a part of the feed grain system. In any case, it is desirable to separate the carry-over of free stocks from commercial feed demand since the amount going into these two uses will be affected differently by varying prices for livestock products, numbers of animal units and grain production.

The carry-over is specified to be partially determined by the current price for feed grain, since high prices tend to move grain into marketing channels if one assumes an elasticity of price expectations less than unity. It is also hypothesized that the previous years
less than unity. It is also hypothesized that the previous years 1
production, $Y_{21_{t-1}}$, will affect storage, with large stocks being carried over after large harvests. In addition to these factors it would be desirable to know the available storage facilities at harvest time as an upper limit to Y_{25}, but such data are not available.
LISE equation for inventory demand with the corresponding standard errors.

$$(5.12) \qquad Y_{25} = -548.3249 - \underset{(.0854)}{.1490}\, Y_{22} + \underset{(.3070)}{1.7392}\, Z_{21}$$

Government Demand

The amount of grain which will be placed under loan or purchase agreement is said to be determined by relationship (5.9). As the spread increases between the national average support price for corn and the market price for feed grains, which would be established in a market where government programs are not in effect, the amount of grain entering government hands will increase. For the years 1929-32, support prices were not in effect and the series was set equal to the actual price index for grain minus eight index points. This in effect places the loan rate for those years sufficiently below the actual price to prevent grain from being placed under loan. The free market price, $Y_{22}*$, is that price which would exist if the same demand factors exclusive of government action were in operation, i.e. with a larger supply being made available for inventory and commercial uses. This increased supply would equal Z_{21} with government demand equal to zero. In this study the current stocks of grain under government control are assumed to have no effect on the market price.

This study also assumes that the level of support prices for corn alone is sufficient to determine the amount of all feed grains going under government control. A refinement to this procedure could be made by estimating the amount of each feed grain placed under loan or purchase agreement using the support prices for each as relevant variables.

The fitting procedure for (5.13) does not account for all simultaneity present in the system. A two equational model is used in which some of the parameters are determined independently of equations (5.5)-(5.8). This assumes that livestock prices and the number of animal units fed are given, although for purposes of simplicity the same endogenous symbols are used. The method of deriving estimating equations for the quantity going under loan and the resulting price is given below.

$$(5.13) \qquad Y_{24} = b_{21} (Z_{20} - Y_{22}^{*}) + u_{24}$$

$$(5.14) \qquad Y_{22} = a_{11} Y_{24} + a_{12} Y_{32} + a_{13} X_{42} + a_{14} Y_{52} + a_{15} Z_{20} - a_{16} Z_{21} + u_{22}$$

Let $Y_{24} = 0$ in (5.14). Then Y_{22} equals the free market price Y_{22}^{*} as given in (5.13). By substituting this value of Y_{22}^{*} in (5.13), Y_{24} may be estimated.

$$(5.15) \qquad Y_{24} = b_{21} Z_{20} - b_{21} a_{12} Y_{32} - b_{21} a_{13} X_{42} - b_{21} a_{14} Y_{52} - b_{21} a_{15} Z_{20} + b_{21} a_{16} Z_{21} - b_{21} u_{22} + u_{24}$$

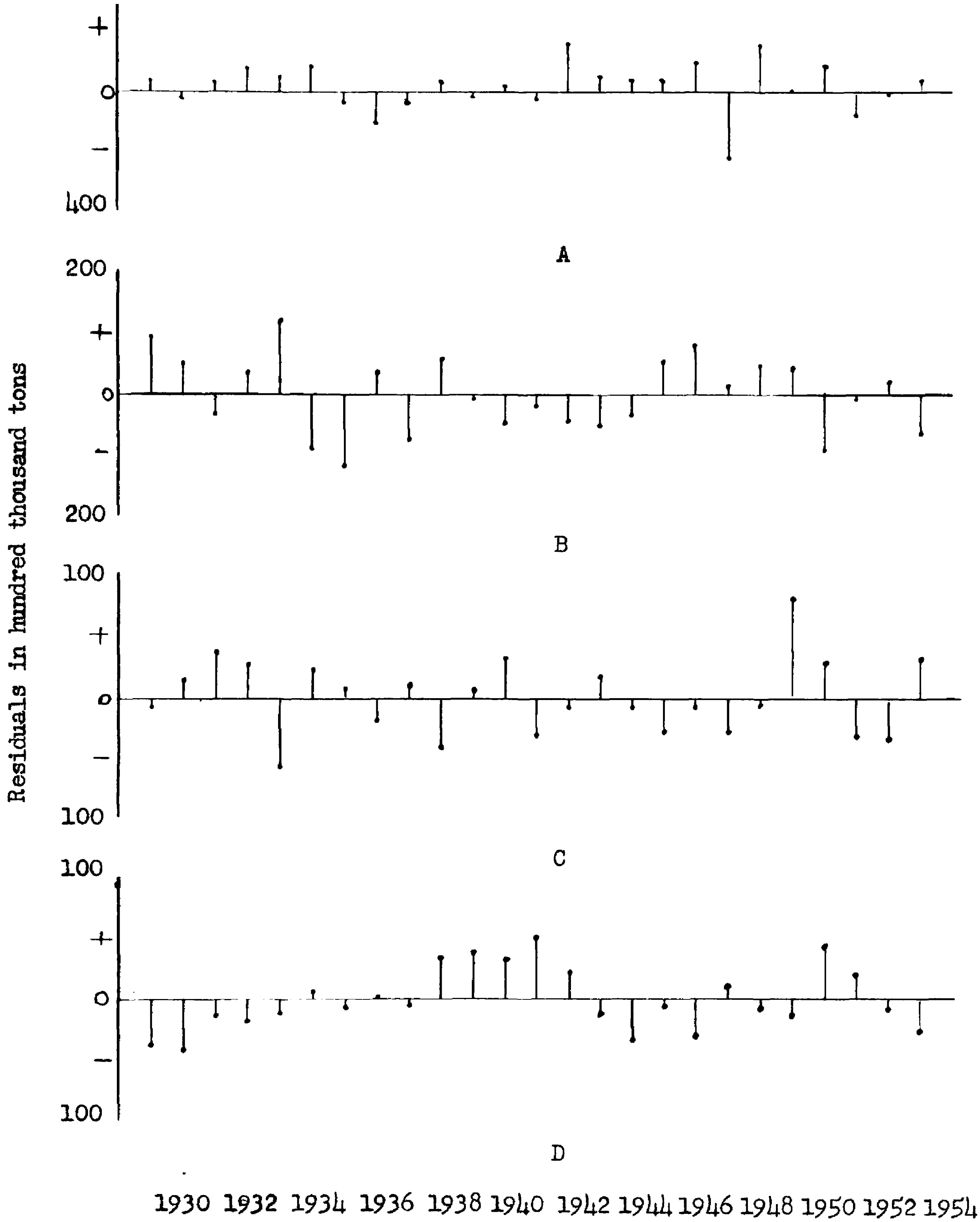

Fig. 1. Unexplained residuals for feed grains.

A. Production

B. Commercial demand

C. Government demand

D. Inventory demand

The random error terms may be combined to give a new random variable, u_{24}'. The least squares solution of this equation yields the following results.

$$(5.16) \quad Y_{24} = 1326.905 + \underset{(.483)}{1.686}\, Z_{22} - \underset{(.336)}{.0335}\, Y_{32} - \underset{(4.221)}{8.434}\, Y_{42} -$$

$$\underset{(.464)}{.184}\, Y_{52} - \underset{(1.054)}{1.160}\, Z_{23} + \underset{(.955)}{.796}\, Z_{21}$$

The coefficient of multiple determination, $R^2 = .60$.

The estimated parameters indicate that increases in livestock prices and the number of animal units will decrease the quantity of feed grain going under loan while increases in the production of feed grain and the support price of corn will increase the quantity of feed grain being placed under government loan.

DAIRY PRODUCTS

The economic structure of the dairy industry is quite complex. As production is a daily operation, producers have a high degree of control over the annual supply. This supply is responsive to milk and feed prices and several studies[5] have been conducted to secure

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[5] H. W. Halvorson, "The Supply Elasticity for Milk in the Short Run," *Journal of Farm Economics*, Vol. XXXVII, December, 1955; G. E. Schuh, *The Supply of Fluid Milk in the Detroit Milkshed as Affected by Cost of Production*, Agricultural Experiment Station, Michigan State University, East Lansing, Technical Bulletin, in process; E. Jensen, *Input-Output Relationships in Milk Production*, United States Department of Agriculture, Washington, D. C., Tech. Bul. No. 815, 1942; J. C. Redman, "Economic Aspects of Feeding for Milk Production," *Journal of Farm Economics*, Vol. XXXIV, August, 1952; J. C. Redman, "Economic Considerations of Grain Roughage Substitution in Feeding for Milk Production," unpublished Ph. D. thesis, University of Kentucky, Lexington, Kentucky, 1951; E. O. Heady, *et al.*, "Isoquants, Isoclines and Economic Predictions in Dairy Production," *Journal of Farm Economics*, Vol. XXXVIII, August, 1956.

input-output data which would indicate the correct feeding rates for given feed prices, milk prices, roughage quality and type of cow.

On the demand side, separate structures exist for several individual dairy products. Butter, manufactured products and fluid milk are influenced differently by the market demand structure and for completeness one should estimate simultaneously the demand relations for each of these products. Though the current study is incomplete in the sense that it aggregates the demand relationships for milk, it does account in part for the several demand outlets.

Supply Relationship

Milk production per cow has increased quite steadily since the early 1930's. This has been due in part to improved feeding practices, better selection of dams and sires by type, upgrading herds through the use of artificial insemination and through the elimination of low producers as determined by Dairy Herd Improvement Associations and Advanced Registry practices. As an indication of such improvements in technology the number of DHIA associations is included. One disadvantage of such a variable is that it may be closely associated with income and therefore as income falls the membership of DHIA's declines also. However, no immediate decrease in production should be apparent since the improved capacity to produce will be inherent and remain for several years.

In this study, pasture and roughage are not included as a feed input. This is not because it has minor importance, but because no satisfactory index converting pasture into feed units has been devised.

A general indication of pasture and roughage condition has been included in the variable Z_{44}, this variable indicating the condition of pasture as a percent of normal for the United States during the months May through October. The number of cows in the producing herd is taken to be the January 1st inventory of cows and heifers two years old and over. A more accurate measure would be the average number of milk cows on farms during the year, excluding heifers that have not freshened. However, the use of such a variable would mean the addition of an equation to estimate this endogenous variable, whereas the chosen variable is predetermined. The January 1st inventory is a logical selection on the grounds that culling of herds is done in the fall months and any cow on hand at the beginning of the year will be milked through the peak production period, April-August.

It is possible that the price of beef is a determinant of the milk supply since low producing cows may be shipped when the price of beef is high relative to that of milk. However, preliminary analyses did not prove this hypothesis. A more conclusive analysis could be used to test this hypothesis if data were available on the number of dairy cows slaughtered.

The limited information estimate of the production of milk is given below.

$$(5.17) \quad Y_{41} = 198.1882 + \underset{(.2120)}{.3687}Y_{42} - \underset{(.0284)}{.1155}Y_{22} + \underset{(.2846)}{.5987}Z_{43} + \underset{(.7080)}{1.9693}Z_{44}$$

$$+ \underset{(.5103)}{2.4250}Z_{46}$$

Y_{41} = Milk production on farms excluding that nursed by calves, in hundreds of million pounds.

Y_{42} = Current annual average price of milk from combined milk and cream marketings in cents per hundredweight.

Y_{22} = Price index for feed grains, 1910-14=100.

Z_{43} = Number of dairy herd improvement associations in United States, $X10^{-1}$.

Z_{44} = Index of pasture condition as percent of 100.

Z_{45} = January 1st inventory of cows and heifers two years old or over in hundred thousand head.

Production appears to be responsive to the prices of milk and feed grains as theoretically specified. The remaining parameters also support the theoretical framework for milk production, with all having the hypothesized sign. The formulation appears to be logical judging by the small standard errors relative to the structural parameters.

Demand Relationship

The demand structure for milk is complex and a detailed study would include several demand functions. The major outlets for milk are as a feed for calves, consumed on the farm, retailed by farmers as milk and cream, and delivered to plants and dealers either as whole milk or as farm skimmed cream. One aggregate demand relationship for milk is constructed with the consumption variable being equivalent to the amount produced. One discrepancy in such a series is the overestimation of consumption by the amount fed to calves but this is a small and fairly constant amount. Since milk is a perishable product from the farmer's standpoint, an inventory relationship is not necessary. Also, because of the manner in which they are operated, government support programs have been omitted.

The demand relationship has the form

(5.18) $(X_{42}, X_{41}/Z_{41}, Z_{42}, Z_{46}, Z_{48}, Z_{49}, u_{42})$

X_{42} = current average annual price for milk, in cents per hundredweight.

X_{41} = milk production on farms excluding that nursed by calves, in hundred million pounds.

Z_{41} = per capita disposable income, in current dollars.

Z_{42} = percent of milk used for manufacturing as against fluid use.

Z_{46} = change in inventories plus net exports of milk products, in tens of million pounds.

Z_{48} = production of oleomargarine, in million pounds.

Z_{49} = average hourly marketing cost for food weighted by functions.

u_{42} = random variable.

The current price of milk is computed by dividing the cash receipts from marketings of all milk and cream by the quantity of milk represented in the marketings. For 1950 and earlier years, it included farm-churned butter. A similar index, varying by a small and fairly constant amount could be constructed by dividing the farm value of milk production by the total production on farms. X_{41} represents total production. Thus elasticities computed with X_{41} rather than the actual amount consumed will represent percentage changes at the farm and one might expect that a more inelastic demand will be present.

Z_{41} reflects two different consumption effects generally called the income and price effects. One could insert the price level as an additional variable to remove the effects on consumption of changes in the price level. The income variable Z_{41} would then represent only the income effects. In this study such a method was used and then discarded because of the high correlation, .96, between Z_{40}, the index of marketing charges and Z_{46}, the price level. Thus the income elasticity which can be derived represents the consumption changes due to both income changes and price level effects.

The per capita disposable income figure is a derived variable from the master model. The master model was solved for Z_{41} and the computed value used in this demand relation. Total disposable income is equal to (total employee compensation) plus, (nonfarm, nonwage income after depreciation and before corporate profit taxes), plus (farm income as estimated by the master model), minus (personal and payroll taxes less transfer payments associated with wage income), minus (personal and corporate taxes less transfer payments associated with nonfarm nonwage income), minus (corporate savings), minus (personal taxes less transfer payments associated with farm income). Such variables were computed for the periods 1929-41 and 1946-53. For the years 1942-45, the actual values of these variables were used since the master model was not deemed applicable for that period. The above derivation of income estimates allows events in the nonagricultural sector of the national economy to influence estimates for the agricultural sector i.e., the demand for agricultural commodities is explained, not by actual income, but by the estimate of that income which the master model generates. This makes it possible to consider income as an endogenous variable when the national economy is viewed and as exogenous to the agricultural sector. Studies from Marshall on have regarded income as endogenous but treated it as being exogenous claiming that the sales of individual commodities have little influence on national income while income does influence the demand for each commodity. The fallacy of such an approach is that while the individual commodity has little effect upon income, i.e. a minute correlation exists between income and the residual term, a bias may still result. This is true where factors outside the market operate on income and also on the residual term thus causing a high correlation between the two. Thus, income should be treated as being endogenous.

Data on Z_{40} are computed by weighting each of the processing, wholesaling, transporting and retailing functions by the total hours worked per week. A base period of 1935-39 was used. The weights[e] were retailing 10.2, transporting 81.6, processing 5.8 and wholesaling 2.3. These weights were applied to the average hourly labor costs for each of the four functions and combined into one index. For the period 1929-1932, average hourly labor costs were not available and these were estimated. The estimation procedure was to form a linear regression equation between

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[e]Data and weights are from unpublished data supplied by Agricultural Marketing Service, United States Department of Agriculture, Washington, D. C., August, 1954.

the series for 1933-53 and the average hourly wage as given in the master model. This regression equation was then applied to the 1929-32 period. Marketing margins and marketing costs are not synonomous but if margins consist of input costs plus an allowance for profit, then it is to be expected that margins and costs move together. The hypothesis used in this analysis is that for given retail prices and the accompanying demand factors, a rise in the marketing cost of food will result in a fall in the price received by farmers.

The percent of milk used for manufacturing as against fluid consumption is chosen to represent the change or trend in utilization since prices are quite different at the two levels. In a more refined model this variable would be further explained since its value is not predetermined for any one year. However, in this analysis its trend value is used. Net exports of milk plus the net change in stocks are included in the present analysis as an exogenous demand factor. The influence of oleomargarine has been strongly felt in the dairy industry and its inclusion here as an exogenous variable is designed to permit the effects of its substitution to be felt. The random component, u_{42}, covers those variables we are unable to specify otherwise. The LISE estimates for this structural equation are given in (5.19). Y_{42} is normalized and the standard errors of the parameters appear in parentheses.

$$(5.19) \quad Y_{42} = 826.5935 - \underset{(.1213)}{.3622Y_{41}} + \underset{(.0850)}{.2457Z_{41}} - \underset{(.0399)}{.0955Z_{43}} -$$

$$\underset{(.7014)}{1.8336Z_{42}} + \underset{(.0264)}{.0743Z_{45}} + \underset{(.0581)}{.0879Z_{46}}$$

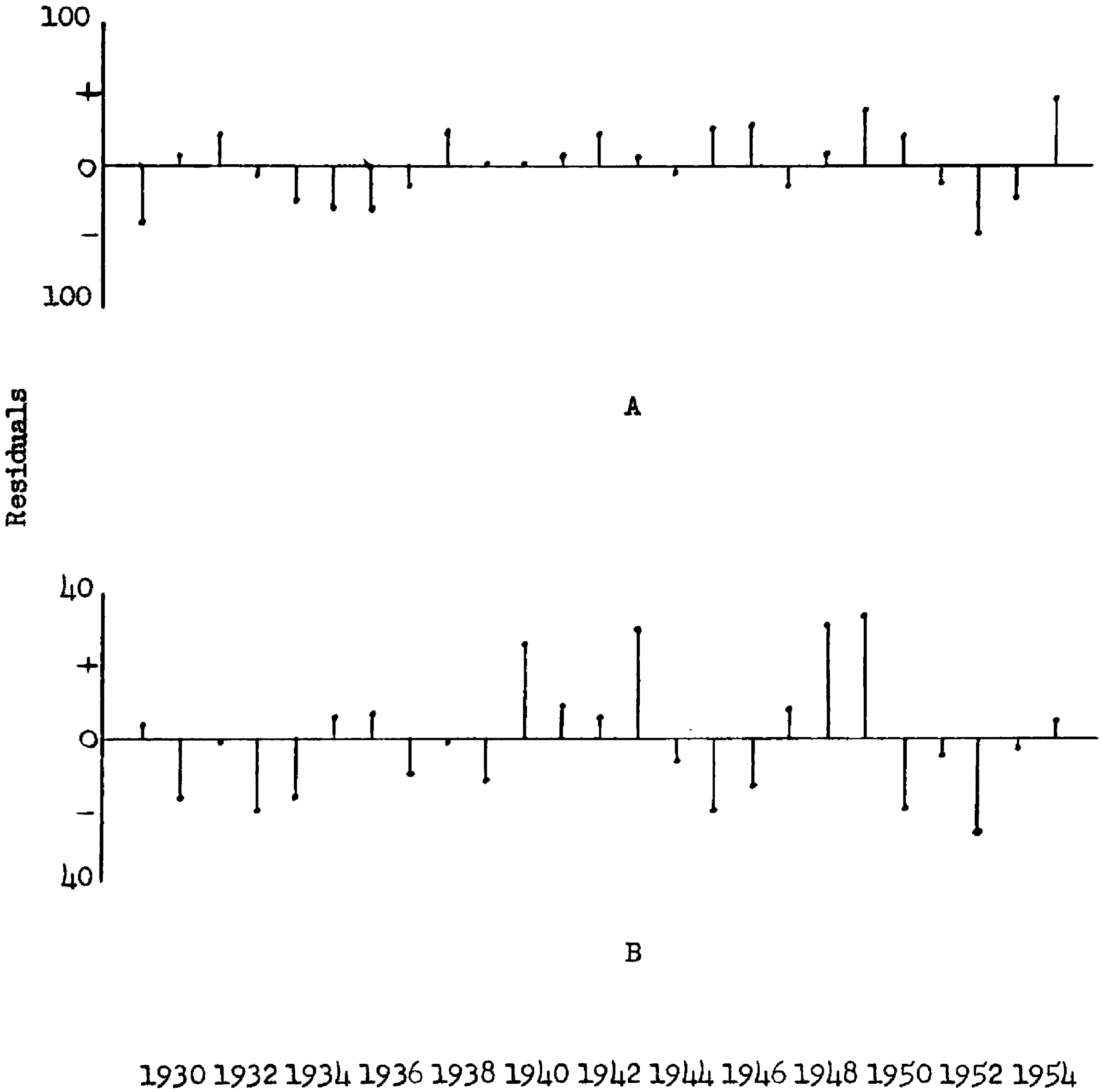

Fig. 2. Unexplained residuals for dairy category.

A. Production - (hundred million pounds)

B. Price - (cents per cwt)

The parameters appear to have signs which support the hypotheses being tested except for the sign on oleomargarine production. It appears that increases in the production of oleomargarine tend to increase the blend price for milk, while observation of the market indicates a contrary influence.

HOGS

A two-equational model is used for the hog category. The behavioral supply function includes the following simplifications which could be made less restrictive by expanding the model.

1. Hog production is assumed equal to (or differs by a constant from) hog slaughterings. This eliminates the inventory problem.

2. No direct government effects are included.

3. A single variable, Z_{ss}, is used to explain the number of pigs farrowed in the spring.

Supply Relationship

The economic structure for hog production is unlike that for beef and dairy cattle inasmuch as two significant production peaks are reached during the calendar year. The production process can also be expanded more rapidly. In addition, hog production is dependent upon corn as the primary feed, hogs consuming approximately one-half of the total production of corn. Hog production is concentrated in the Corn Belt States and North Central region because of this fact, and one may expect that variations in corn supplies or prices will cause a contraction or expansion in hog production. An additional complication exists since a portion of the supply may be farrowed and marketed within the calendar year. This means that in addition to a supply equation based on beginning year numbers, one must account for the number of pigs farrowed during the spring farrowing period. Hogs farrowed in the spring months, mainly April and May, will reach their marketing weight by the end of the year, and hogs farrowed during the fall months normally reach market by March or April of the following year. This means that slaughter during the current annual year, as defined in this model, will depend, in part, upon producers' decisions during the previous year, and also that behavior will not be reflected in slaughter estimates until the following year. Besides the flexibility of production due to changing numbers, producers may obtain additional flexibility by varying the marketing weight of hogs. For hogs farrowed in the spring, it is theorized that late fall marketings will be influenced by the current price of hogs and by available feed supplies. Feed prices are not believed to be as important as feed supplies for two reasons. Farmers tend to feed hogs to marketing weights of approximately 200-220 pounds regardless of feed prices, with feeding rates beyond this range being dependent upon the relative prices of feed and hogs. In addition, hogs can utilize feed of low quality such as soft corn or low grade grains. Supplies of such feeds may exert more influence than do their prices. Hog prices are important since they determine, in part, the decision of when to market. High prices may encourage earlier marketings since, unlike cattle, hogs are not readily adaptable to extended feeding. Grades and prices may decline rapidly as higher weights are reached.

Feed supplies of the previous year are important since this represents the available feed for those hogs slaughtered in the spring. In addition, feed supplies of the previous year influence the number of sows bred to farrow in the spring of the current year. The number of sows and gilts on hand January 1st of the current year is included as the determinant of the level of pigs farrowed in the spring.

The supply relationship is as follows:

$(Y_{61}, Y_{62}, X_{61} / Z_{61}, Z_{66}, u_{61})$

Y_{61} = liveweight slaughter of hogs in tens of million pounds.

Y_{62} = price of hogs, in cents per hundred pounds.

X_{61} = production of feed grains beginning July following January of year t.

Z_{61} = available supply of feed grains, in tons $X10^5$.

Z_{66} = January 1st inventory of sows and gilts, in tens of hundred thousands.

u_{61} = random variable.

The LISE parameter estimates with their corresponding standard errors are given below.

$$(5.20) \quad Y_{61} = -320.656 + \underset{(.083)}{.181Y_{62}} + \underset{(.258)}{.344X_{61}} + \underset{(.446)}{.204Z_{61}} + \underset{(3.859)}{12.845Z_{66}}$$

<u>Demand Relationship</u>

The aggregative demand for pork is considered to be similar to that for beef. Beef and poultry meats are assumed to be substitutes for pork in consumption and their prices are included for this reason. Income and marketing costs for food as developed on pages 53-54 make up the remaining variables.

(5.21) $(Y_{52}, Y_{51}, Y_{32}, Y_{72} / Z_{41}, Z_{49}, u_{52})$

Y_{52} = price of hogs, in cents per hundred pounds.

Y_{51} = liveweight slaughter of hogs, in tens of million pounds.

Y_{32} = price of beef, in cents per hundred pounds.

Y_{72} = price of poultry meats, in cents per pound.

Z_{41} = per capita disposable income, in current dollars.

Z_{49} = average hourly marketing cost for food.

u_{52} = unexplained random variable.

The limited information estimates for relationship (5.21) are as follows with the standard errors of the parameters given in parentheses.

$$(5.22) \quad Y_{52} = -371.386 - \underset{(.221)}{.304Y_{51}} - \underset{(.172)}{.059Y_{32}} + \underset{(19.230)}{68.959Y_{72}} + \underset{(.887)}{.054Z_{41}} + \underset{(.512)}{.513Z_{49}}$$

From these results one could deduce that poultry meat but not beef is a substitute for pork in the consumer's diet. The correct sign appears on the per capita income parameter although its standard error is large. The farm price decreases with a rise in current annual slaughterings as one would hypothesize. However, it does appear that given the level of all other factors an increase in the cost of marketing food causes an increase in the farm price of hogs. This result is contrary to what one would expect. One interpretation is that Z_{49} not

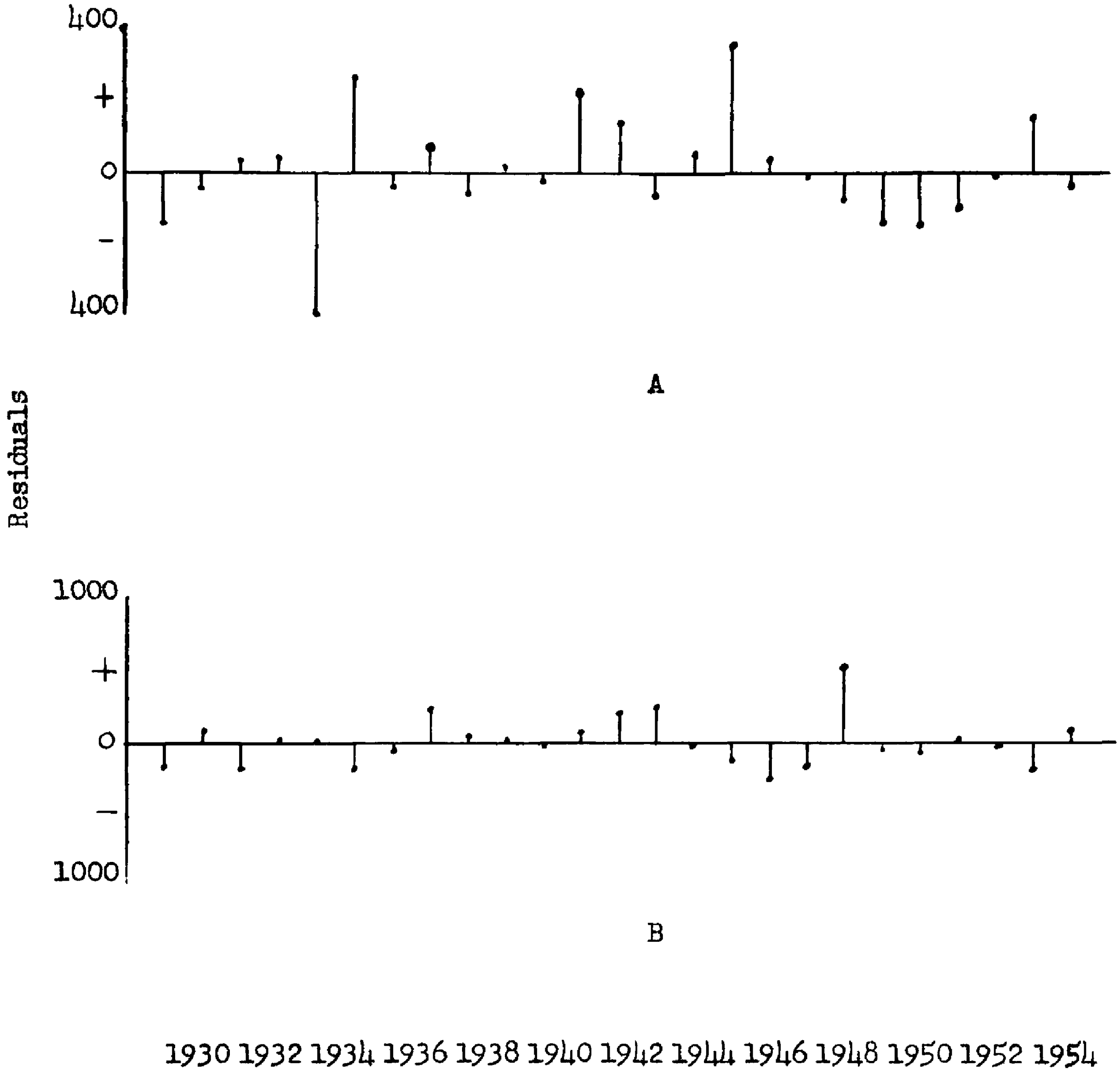

Fig. 3. Unexplained residuals for hog category

A. Production - (tens of million pounds)

B. Price - (cents per ten pounds)

only represents an index of marketing costs but also an index of the general price level since the two are highly correlated. Thus the effect of Z_{40} is to explain the increase in pork prices due to price level changes since pork prices are in current dollars.

POULTRY MEATS

Poultry meats and eggs are considered as separate categories because producer behavior differs widely for the two categories. A complete commodity analysis would include different supply functions for turkey, broiler and chicken meat. Broiler production has become highly specialized since the middle 1930's, and this along with the seasonal nature of turkey production requires the use of a different supply function than that used for eggs. Included in the poultry meats category are broilers, chickens and turkeys.

Supply Relationship

The supply relationship used is of the following form.

(5.23) $(Y_{71}, Y_{22} / Y_{72,t-1}, Z_{72}, u_{71})$

Y_{71} = production in tens of million pounds, liveweight, of broilers, turkeys and chickens.

Y_{22} = index of feed grain prices for the year beginning the previous October.

$Y_{72,t-1}$ = price of broilers during the previous year, in cents per pound.

Z_{72} = technology trend as given by the physical units of poultry house equipment.

Z_{65} = January 1st inventory of hens and pullets on farms, in millions.

U_{7t} = unexplained random variable.

Production data are acquired by summing the production figures for each of the three products, broilers, turkeys and chickens. This variable is again used in the demand equation which requires the assumption that production equals consumption. The price of feed grains relative to poultry meat prices during the previous fall partially determines the number of broilers, turkey poults and chickens which are hatched in the spring. In addition, the relative prices of feed grains and poultry meats influence current feeding rates. Though it would be accurate, conceptually, to use poultry ration prices rather than those for feed grain, the choice is of little practical significance as the two follow similar price movements.

The price of broilers, lagged one year, is included as a separate variable in an attempt to explain some of the market differences between turkeys and broilers. Since broiler production is conducted on an approximate three-month basis, an attempt to capture some of this flexibility in production is made by including lagged broiler prices.

The production of poultry meats has been aided greatly by technical advances in nutrition, breeding and disease control. It is difficult to measure such advances and as a substitute measure, Z_{73}, is used to indicate the nature of the technology trend. The series used is an index of the number of units sold by manufacturers of different types of poultry house equipment. Another change not easily captured in this model is the present tendency for feed companies to have their broilers raised on contract with producers who furnish only labor and equipment.

Several different preliminary fits were made which included the beginning inventories of turkey hens, hens and pullets for laying purposes, and the current price of eggs. In the fitted equation the January 1st inventory of hens and pullets was retained. The LISE parameter estimates with the corresponding standard errors are given in (5.24).

$$(5.24) \qquad Y_{71} = 299.844 - \underset{(.039)}{.226}Y_{82} - \underset{(.300)}{.646}Z_{66} + \underset{(.673)}{6.329}Z_{75} + \underset{(2.431)}{10.427}Z_{75-1}$$

Except for Z_{66} all parameter signs are consistent with the specified hypotheses. The negative parameter on Z_{66} could well be a result of incomplete specification. The factors influencing the rate of culling have an important effect in determining when the producing flocks are to be marketed and therefore a large beginning inventory is not necessarily an indication that current annual marketings will be of equal magnitude.

Demand Relationship

The demand relationship for poultry meats is specified to include the following variables.

$$(5.25) \qquad (Y_{72},\ Y_{71},\ Y_{82}/Z_{41},\ u_{72})$$

Y_{72} = price of poultry meats, in cents per pound.

Y_{71} = production of poultry meats, liveweight, in tens of million pounds.

Y_{82} = price of hogs, in cents per hundred pounds.

Z_{41} = per capita disposable income, in current dollars.

u_{72} = unexplained random disturbance.

The above relationship assumes that production and consumption of poultry meats are equal.

The price index for poultry meats is weighted by the average price ratios of the three commodities for the period 1947-49. Chicken prices are given a value of 100, turkeys 130, and broilers, 126. The assumption is made that these three commodities are substitutable in production and consumption and, therefore, that their price ratios should equal their marginal rates of substitution in consumption. These marginal rates of substitution then act as weights.[1]

Hog prices are included since there may be an appreciable substitution between consumer purchases of pork and poultry meats. Per capita disposable income indicates consumer purchasing power. The LISE estimates of the parameters in (5.25) were very unsatisfactory having a negative value for Z_{32} and a positive value for Y_{71}. The rapid improvement made in production techniques, the quality of poultry meat, and the methods of marketing may be partially responsible for this. The subsequent least squares fit is given below in (5.26) where poultry meat production and hog prices are assumed to be exogenous values.

$$(5.26) \qquad Y_{72} = 11.32 - \underset{(.0170)}{.0173}Y_{71} + \underset{(.0028)}{.0077}Y_{82} + \underset{(.0085)}{.0107}Z_{41}$$

The adjusted coefficient of multiple determination for this relationship equals .87.

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[1] An alternative price index using quantity weights of the Laspeyres type was computed on a 1947-49 base, and was almost identical to the included price series.

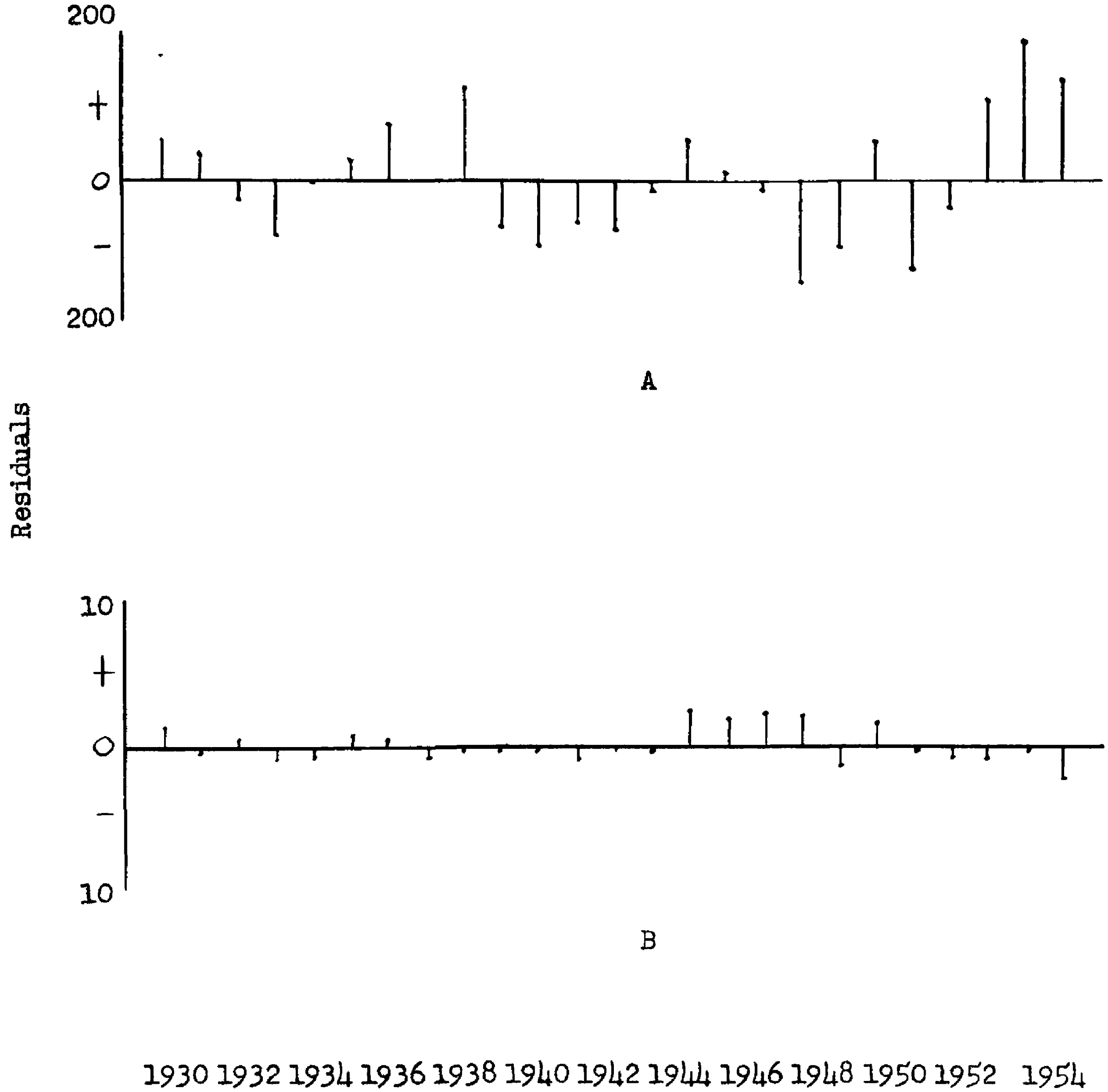

Fig. 4. Unexplained residuals for Poultry meat category.

A. Production - (tens of million pounds)

B. Price - (cents per pound)

EGGS

In recent years the poultry enterprise has undergone substantial changes. Improved breeding, feeding, management and disease control practices have resulted in an increase in the size of farm flocks and more specialization in egg production. Because of these improvements, the rate of lay per hen has risen almost constantly in the time period being studied.

The following relationships are constructed to explain producer and consumer behavior.

Supply Relationship

(5.26) $(Y_{e1}, Y_{s2}/Z_{e5}, Z_{e3}, Y_{e2_{-1}}, u_{e1})$

Y_{e1} = production of eggs, in hundred millions.

Y_{s2} = index of feed grain prices, 1910-14 = 100.

Z_{e5} = January 1st inventory of hens and pullets on farms, in millions.

Z_{e3} = technology trend as given by number of birds in NPIA, in hundred thousands.

$Y_{e2_{-1}}$ = price of eggs on December 15th of year t_{-1}, in cents per dozen.

u_{e1} = random disturbance.

The above supply function assumes that the included variables explain (1) the egg production of hens and pullets on farms on January 1st and (2) the number of pullets to be hatched and kept for laying purposes during the year. Feed grain prices are lagged three months and the December 15th price of eggs is used. The hypothesis is that these two factors partially determine the number of chicks to be hatched in the spring. Current egg prices are not included in this formulation, it being hypothesized that producers tend to feed at certain rates regardless of current egg prices.

The technological developments in egg production, as mentioned above, are indicated by the Z_{e3} variable. It would be difficult to use any one or even a small number of variables which would completely specify the nature of the technological improvements. The choice of Z_{e3} is arbitrary but represents a better indicator than would a simple time trend. Suggestions have been made to use "rate of lay per bird," rather than Z_{e3}, since it is affected by disease control, genetic improvement and improved management. However, rate of lay per bird is a combination of the number of layers on hand during the year and total production. Both of these factors are dependent upon egg prices and poultry meat prices which makes rate of lay per bird endogenous to the model. Preliminary tests were made to measure the rate of culling by including the current prices of poultry meat and eggs. No satisfactory relationship could be established, perhaps because culling is determined by seasonal or institutional, as well as price phenomena.

A limited information fit for this supply relationship was computed as given below in (5.27) with the standard errors of the parameters given in parentheses.

$$(5.27) \qquad Y_{e1} = 46.56 - \underset{(.038)}{.063Y_{e2}} + \underset{(.094)}{.669Z_{e3}} - \underset{(.183)}{.641Z_{e6}} + \underset{(1.838)}{3.663Y_{e2-1}}$$

All parameters appear to have the correct signs as specified in the theoretical framework.

Demand Relationship

The demand relationship is computed with the farm price of eggs normalized. The supply of eggs should inversely affect this price while increases in consumer income should strengthen it. Increases in marketing costs decrease the farm price if other demand factors are given. It is difficult to hypothesize the commodities which should be included as substitutes in consumption. In this analysis dairy products are included as competitors.

(5.28) $(Y_{e2}, Y_{42}, Y_{e1} \,/\, Z_{41}, Z_{40}, u_{e2})$

Y_{e2} = price of eggs, in cents per dozen.

Y_{42} = price of milk, in cents per hundredweight.

Y_{e1} = production of eggs, in hundred millions.

Z_{41} = per capita disposable income, in current dollars.

Z_{40} = average hourly marketing cost for food weighted by the wholesaling, processing, retailing and transportation functions.

u_{e2} = unexplained random disturbance.

The LISE parameter estimates are given in (5.29)

$$(5.29)\quad Y_{e2} = 19.258 - \underset{(.076)}{.0621Y_{e1}} + \underset{(.058)}{.0524Y_{42}} + \underset{(.041)}{.0493Z_{41}} - \underset{(.012)}{.0161Z_{40}}$$

The parameter signs fit the hypotheses although the standard errors of all are large.

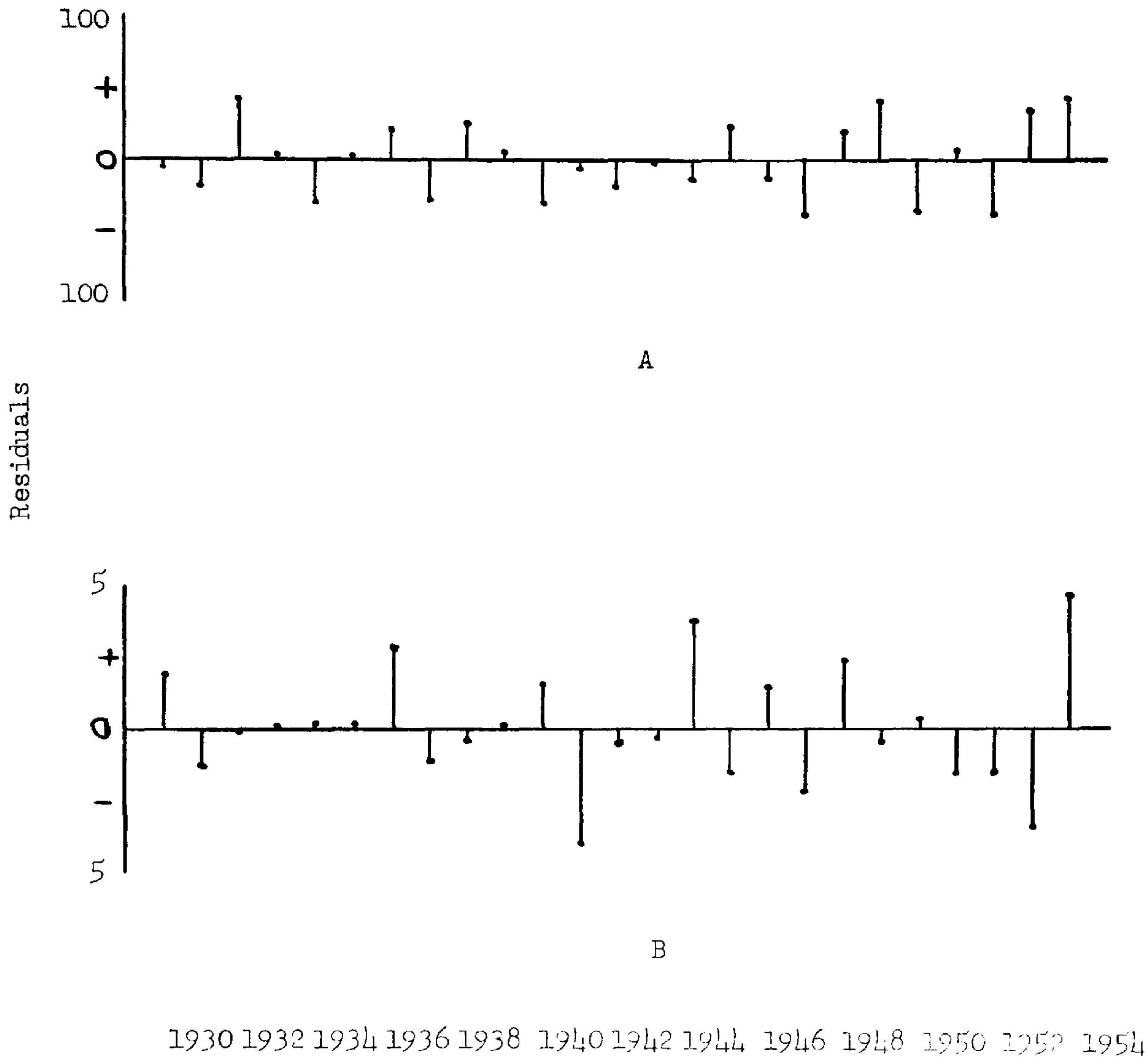

Fig. 5. Unexplained residuals for egg category.

A. Production - (hundred millions)

B. Price - (cents per dozen)

BEEF CATTLE

Many attempts have been made to explain the beef cattle economy. It is very complicated for several reasons, one being that it is not a unique sector but includes, what could be termed, byproducts of the dairy industry. Dairy cattle make up a large percentage of the total beef slaughter and such phenomena must be incorporated into explanations of the "beef economy." A cattle cycle also prevails. Regardless of other economic factors, beef supplies increase and decline due to biological causes. It takes roughly eighteen to twenty-four months to raise a calf to the breeding age, and another two, three, or four years to produce a marketable steer. Such a life cycle makes it difficult to increase the number of cattle in the short run. In addition, "breeding herd" may be sold causing temporary increases in supply followed by large decreases.

Supply Relationship

The above cursory discussion reveals that many facets of study face those who undertake economic research in beef production and marketing. Preliminary studies were made to reveal the structure of beef production. Since the category is a composite of several products, one should specify several supply functions if completeness is desired. By tracing the disposition path of calves through the use of accounting identities, the several production outlets are discovered. Production relationships can then be specified for bull calves, heifer calves, steers, cows and heifers, and bull and stags. Though several attempts were made in this area with some success, the complexity of the problem made it unmanageable. As a result, the present investigation has concentrated on specifying <u>one</u> supply function for all beef cattle, including dairy cattle slaughtered. This is expressed by the following relationship.

(5.30) $(Y_{31}, Y_{32} \,/\, Z_{34}, Z_{35}, Z_{s1}, u_{31})$

Y_{31} = liveweight slaughter of beef, in million pounds.

Y_{32} = price of beef, in cents per hundred pounds.

Z_{34} = index of range condition, where 100 equals normal.

Z_{35} = hundred thousand head of steers and calves on hand January 1st.

Z_{s1} = supply of feed grains available for use, beginning October 1st of year t_{-1}.

u_{31} = random variable.

This fitted equation with the corresponding standard errors is given below.

$$(5.31) \quad Y_{31} = -10073.262 + \underset{(.645)}{.528Y_{32}} + \underset{(66.745)}{129.239Z_{34}} + \underset{(1.815)}{11.090Z_{35}} - \underset{(3.213)}{3.502Z_{s1}}$$

<u>Demand Relationship</u>

The demand for beef represents demand for total meat and this has been increasing as compared to non-beef meats. The farm price is associated with the supply of beef, prices of close substitutes, per capita income and the intervening marketing costs.

(5.32) $(Y_{32}, Y_{31}, Y_{22} \,/\, Z_{41}, Z_{48}, u_{32})$

Y_{32} = price of beef, in cents per ten pounds.

Y_{31} = liveweight slaughter of beef in million pounds.

Y_{22} = price of pork, in cents per hundred pounds.

Z_{41} = per capita disposable income, in current dollars.

Z_{48} = average hourly marketing costs for food.

u_{32} = random disturbance.

The LISE parameter estimates with the corresponding standard errors are given in (5.33).

$$(5.33) \quad Y_{32} = 687.789 - \underset{(.025)}{.094}Y_{31} + \underset{(.262)}{1.000}Y_{22} + \underset{(.693)}{.444}Z_{41} + \underset{(.333)}{.547}Z_{48}$$

All parameters appear reasonable except for Z_{48} where the same interpretation may be given as in the case of hog and dairy prices, i.e., it represents the change in the farm price of beef due to price level changes. Since Y_{31} is assumed to be equal to consumption, no account has been taken of changes in meat inventories. Poultry meats were not specified as substitutes in the consumer diet due to the findings of previous research workers who dealt with the demand for beef.*

The preceding six product categories represent a complete system of equations, i.e. n equations plus identities in n unknowns. To use the system for analytical purposes the n equations in n unknowns must be solved for using the estimated coefficients. A general method of solution is outlined in Chapter XII followed by an actual example.

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*K. A. Fox, The Analysis of Demand for Farm Products, United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., Technical Bulletin No. 1081, 1953.

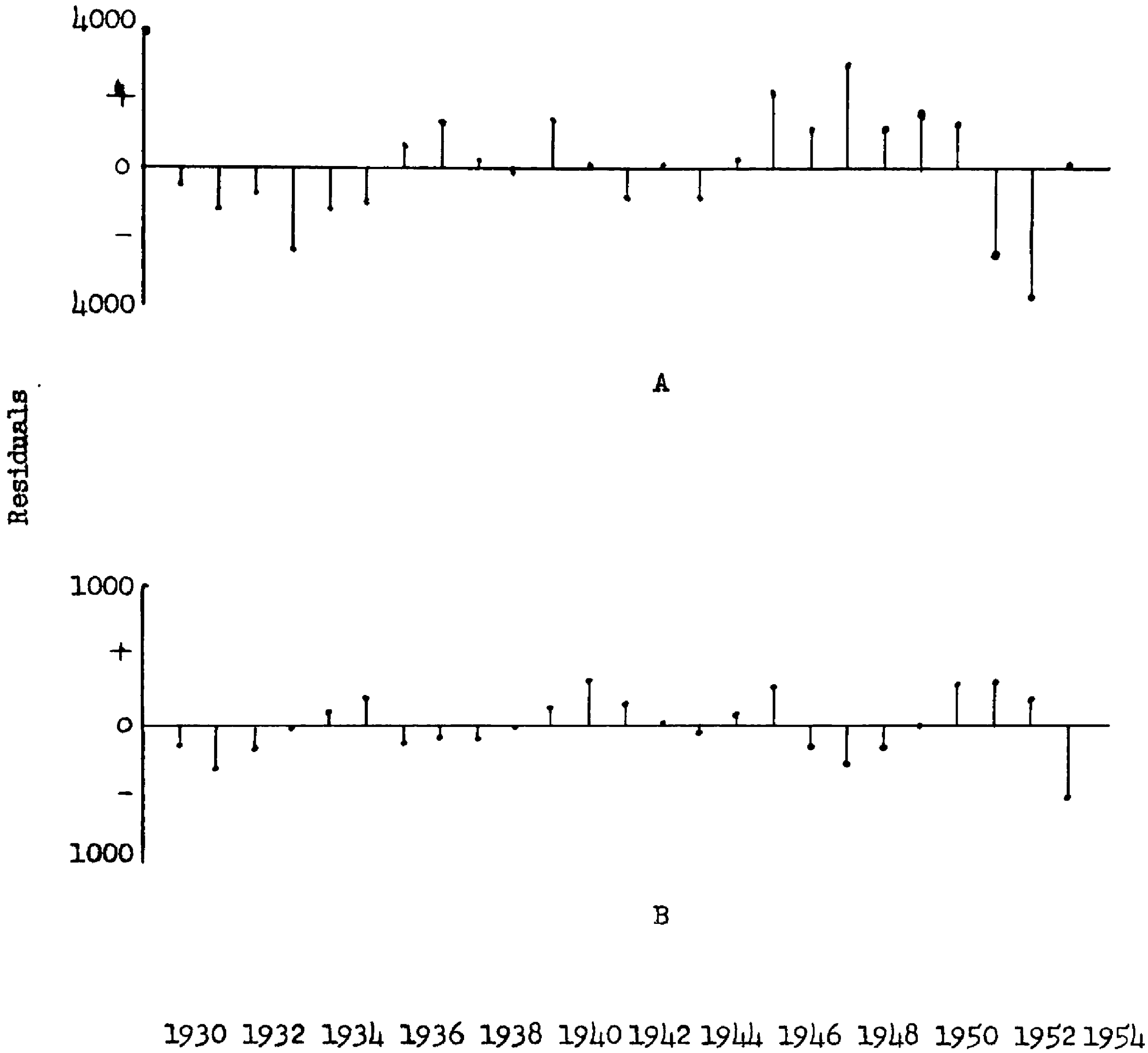

Fig. 6. Unexplained residuals for beef category.

A. Production – (million pounds)

B. Price – (cents per hundred pounds)

CHAPTER VI

WHEAT

Wheat is one of the most valuable crops grown in the United States, both, as a domestic and as an export commodity. Its nature as a product permits it to be stored, exported, consumed as a food for humans and livestock, and used for industrial purposes. This obviously complicates any analysis of its production and use. The economic model for wheat would be still more complicated if an analysis of each of the several classes was undertaken, e.g. hard red winter, soft red winter, etc. For this study wheat is treated as one homogeneous commodity, based upon a July crop year.

Supply Relationship

The production of wheat,[1] as of all crops, is determined by the acreage harvested and the yields per acre. For the period under study no marked trend in harvested or planted acreage is apparent. However, some large variations in the year to year acreage harvested do occur. Such variations depend largely upon climatic conditions as they affect the planting, growing and harvesting processes. Other factors of

[1] A very thorough discussion of the factors affecting both production and demand for wheat is to be found in the U.S.D.A. Tech. Bull. 1136. K. W. Meinken, The Demand and Price Structure for Wheat, United States Department of Agriculture, Washington, D. C., Tech. Bull. 1136, November, 1955.

importance are the acreage allotments (which create some rigidity in acreage planted and harvested), the expected prices of wheat and alternative crops, and the development and availability of machinery specialised for use in wheat production. Yields of wheat are also affected by some of these variables, weather being by far the most important. Price expectations influence fertiliser applications, while machinery design and investment permit planting and harvesting at more appropriate times. In addition the development of new varieties, pesticides and improved cultural practices also affect yields.

As in previous crops relationships dealing with the acreage planted and production were constructed and then a reduced form resorted to in deriving a single production relationship.

(6.1) $(Y_{11}, Y_{12}/Z_{84}, Z_{81}, Z_{12}, Z_{13}, u_{11})$

(6.2) $Y_{12} = B_1 Z_{84} + B_2 \left[\frac{Y_{11}}{Y_{12}}\right]_{-\bar{3}} - B_3 Z_{81}$

(6.3) $Y_{11} = \alpha \left(Z_{84}, Z_{81}, Z_{12}, Z_{13}, \left[\frac{Y_{11}}{Y_{12}}\right]_{-\bar{3}}\right)$

Y_{11} = million bushels of wheat produced.

Y_{12} = hundred thousand acres planted to all wheat, or amount of allotments when in effect.

Z_{12} = thousand tons of fertiliser applied in North Dakota and Kansas.

Z_{13} = unharvested acreage of wheat, in hundred thousand acres.

Z_{84} = index of numbers of tractors and combines on farms.

Z_{81} = time, 1929=0.

$\left[\dfrac{Y_{11}}{Y_{12}}\right]_{-3}$ = weighted average of the ratio of wheat prices to feed grain prices for the three preceding years. 1910-14=1000.

u_{11} = random disturbance.

The first relationship associates production with the acreage planted and those factors which affect both the yield and the harvested acreage. As explained above, climatic factors are most important in this respect. Since no direct measures of weather effects are available, an attempt is made to measure such variations by including the unharvested acreage. The implicit assumption is that adverse climatic conditions increase the acreage not harvested.

Changing cultural practices are measured by using a linear trend variable Z_{61}, while the level of machinery investment is measured by including the variable Z_{24}, an index of the numbers of tractors and combines on farms. The final variable Z_{19} was included as a measure of the intensity of fertilizer application on farms in the major wheat growing areas.

Since acreage is an endogenous variable, the variables with which it is associated are given in relationship (6.2). The level of machinery investment is included as an indication of producers' ability to handle expanding acreages. If any trend in acreage is apparent it was hoped that it would be picked up by a time variable, Z_{61}.

The effect of product-product substitutions which may occur between wheat and alternative crops is introduced by the price ratio of wheat and feed grains for a preceding period. This in effect is said to measure relative price expectations for the two crops. This variable was constructed as follows: The prices of both crops were put on a 1910-14 index. The ratio of wheat prices to feed grain prices was computed and lagged three years. Such a value was given a weight of 1/6, the ratio lagged two years, was given a weight of 1/3, and the ratio for the preceding year was given a weight of 1/2. The sum of these weighted ratios represents the variable $\left[\frac{Y_{11}}{Y_{12}}\right]_{-\bar{3}}$.

The third relationship expresses production as a function of factors which may be considered predetermined. Z_{61} was omitted in the fitted equation. The reason for omission was that while a positive sign is expected on Z_{61} in (6.1), a negative sign might be expected in (6.2) after acreage allotments are imposed. In addition the variables, Z_{24}, and Z_{61}, follow a similar trend so that little additional information can be gained by including both. Z_{24} was used since it yields a quantitative measurement of part of the influences involved, whereas Z_{61} represents several influences none of which are assumed to be directly measureable. The fitted equation with the standard errors of the estimated parameters is given in (6.4).

$$(6.4) \quad Y_{11} = 910.64 - \underset{(.388)}{2.184}\, Z_{13} + \underset{(.975)}{1.701}\, Z_{12} + \underset{(2.085)}{.094}\, Z_{24} + \underset{(.113)}{.116} \left[\frac{Y_{12}}{Y_{22}}\right]_{-\bar{3}} \qquad \bar{R}^2 = .78$$

<u>Demand Relationships</u>

The forces which generate the demand for wheat are complex and success in measuring their effects depends upon a separation of the several demands for wheat. Based upon disposition, several separate demand relationships have been specified in this model. These are (1) commercial demand which includes domestic food and livestock feed uses, (2) demand for wheat to store privately, (3) government inventory demand and (4) an export demand. The first three of these are dealt with in some detail. Wheat exports are considered predetermined inasmuch as many non-economic factors of an international nature are involved in their determination. Thus, beginning with the production of wheat, supply and disposition identities may be set up as in equations (6.5) and (6.6) prior to dealing with the three separate demand relationships.

$$Y_{11} + Y_{16_{-1}} - Z_{14} = Y_{11}^{*} \qquad (6.5)$$

$$Y_{11}^{*} = Y_{15} + Y_{16} + Y_{17} \qquad (6.6)$$

Y_{11} = wheat production, in millions of bushels.

$Y_{16_{-1}}$ = beginning inventory of wheat not under CCC loan, in million bushels.

Z_{14} = net exports of wheat, in million bushels.

Y_{11}^{*} = supply, exclusive of government stocks, available for utilization, in million bushels.

Y_{15} = wheat used domestically for food, feed, seed and industrial purposes, in million bushels.

Y_{16} = year-end carry-over of wheat, in million bushels.

Y_{17} = wheat delivered to CCC, in million bushels.

Commercial Demand

As seen from the definition of Y_{15} above, the commercial demand for wheat includes that utilized in several ways and a complete analysis would include more details on each of these demand categories. What is attempted in this model is to treat these several demand outlets as an aggregate and attempt to isolate and measure the important demand factors for the group.

It is known that per capita consumption of wheat for food has declined during the past two decades, as the composition of bread changed and more milk, fruits, vegetables and foods with a low starch content were consumed. Within products manufactured from wheat, there appears to be a substitution between wheat consumed as bread in favor of that consumed as bakery products as per capita income rises.[a] In addition to income the real price of wheat would be expected to influence consumer purchases of wheat products. For this purpose both Y_{12}, the farm price, and Z_{26}, the price level are included. To eliminate some of the spread between retail and farm prices the marketing cost index, Z_{40} is also included. Changes in tastes due to the ethnic composition, age and geographic distribution of the population are included as a trend factor Z_{51}.

The demands for industrial and feed purposes are largely determined by the relative prices of wheat and corn which is a major substitute in both uses. Since in this analysis, corn prices (as represented in the feed grain price index) are not estimated except for the current crop year, the production of feed grains was used to measure this factor-factor substitution.

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[a] *Ibid.*, p. 17.

The demand relationship is given in (6.7).

(6.7) $(Y_{15}, Y_{12} \,/\, Z_{40}, Z_{41}, Z_{36}, Y_{21}, Z_{61}, u_{15})$

Y_{15} = wheat used domestically for food, feed, seed and industrial purposes, in million bushels.

Y_{12} = average market price of wheat to growers, in cents per bushel.

Z_{40} = average hourly marketing cost for food index, weighted by functions.

Z_{41} = per capita disposable income, in current dollars.

Z_{36} = index of the general level of prices for United States, 1939=100.

Y_{21} = production of feed grains, in hundred thousand tons.

Z_{61} = time trend, 1929=0.

u_{15} = random disturbance.

Y_{21} is treated as a predetermined variable. In order to consider it endogenously a simultaneous solution of the wheat and feed grains product categories would have to be made. However, too few observations exist to permit a simultaneous solution of the present models to be reached. When Y_{15} is considered dependent, the LISE computation of the parameter values are as given in (6.8).

$$(6.8)\quad Y_{15} = 883.606 - \underset{(1.278)}{3.008}\, Y_{12} - \underset{(.174)}{.129}\, Y_{21} - \underset{(.430)}{.597}\, Z_{40} + \underset{(.575)}{1.214}\, Z_{41} -$$

$$\underset{(7.396)}{1.179}\, Z_{36} + \underset{(15.543)}{6.836}\, Z_{61}$$

While the signs on the parameters are correct the standard errors of some are very large. In particular, when Z_{61} was omitted the fitted relationship did not improve as the signs on Y_{21} and Z_{36} became positive.

Inventory Demand

The annual fluctuations in production coupled with the nonperishability of wheat creates a demand for storage on the part of farmers and processors. If the price expectations of those people holding wheat are elastic, storage will occur. Such expectations are usually held when the size of the current crop is above average. This generally depresses current prices and creates a speculative demand in the form of storage. The one factor which permits some estimation of future production is the acreage planted to winter wheat which can be estimated or known sometime early in the crop year. However, this acreage does not indicate production very reliably since climatic conditions will cause some difference to exist between planted and harvested acreage as well as influence yields.

The inventory demand relationship is given in (6.9).

(6.9) $(Y_{16}, Y_{11}{}^{*}, Y_{18} \;/\; Z_{16}, u_{16})$

Y_{16} = year end carry-over of wheat (excluding CCC stocks), in million bushels.

$Y_{11}{}^{*}$ = supply of wheat available for utilization, exclusive of government stocks, in million bushels.

Y_{18} = average market price of wheat received by growers, in cents per bushel.

Z_{16} = acreage planted to winter wheat, in hundred thousand acres.

u_{16} = random disturbance.

The equation fitted by the LISE procedure results in the following parameter estimates, when Y_{16} is considered to be dependent.

$$(6.10) \quad Y_{16} = 113.619 + \underset{(.113)}{.266}\, Y_{11}^{*} - \underset{(.296)}{.969}\, Y_{18} - \underset{(.315)}{.099}\, Z_{16}$$

The parameter signs are as hypothesized, although that for Z_{16} does not differ significantly from zero.

Government Demand

Beginning with the year 1938 and continuing in some form until the present time a price support program has been in operation for wheat. Where the quality of wheat permits, and where storage facilities are available, the market price may be expected to approximate a level at least as high as the support price less storage costs. The analysis for government demand is patterned after that used for the feed grains product category i.e., the amount of wheat placed under loan is determined by the difference between the national average support price and what the price would be in the absence of government support operations. Since this latter price—the "free" market price—is an hypothetical one, being determined by supply and demand conditions in the absence of government intervention, it cannot be measured directly; hence it is solved for in terms of observable variables. Such a procedure is provided by the structural equations given in (6.11) and (6.12) where the parameter signs are included to show the effect of going to a reduced form.

$$(6.11) \quad Y_{17} = a_1 \left[Z_{16} - Y_{11}^{*}\right] + u_{17}$$

$$(6.12) \quad Y_{11} = b_1 Y_{17} - b_2 Y_{21} + b_3 Z_{41} - b_4 Z_{40} + b_5 Z_{36} - b_6 Y_{11}^{*} + u_{11}$$

Y_{17} = quantity of wheat delivered to CCC, in million bushels.

Z_{16} = national average support price for wheat, in cents per bushel.

Y_{12}^{*}= "free" market price of wheat, in cents per bushel.

Y_{12} = average market price of wheat to growers, in cents per bushel.

Y_{21} = production of feed grains, in hundred thousand tons.

Z_{41} = per capita disposable income, in current dollars.

Z_{40} = index of average hourly marketing charges for food, weighted by functions.

Z_{26} = price level index for United States, 1939=100.

Y_{11}^{*}= supply of wheat available for utilization, excluding CCC stocks, in million bushels.

u_{17}, u_{12} = random disturbances.

For those years where support prices were not in effect they were estimated at a level eight cents per bushel below the market price. It was assumed that government demand would be zero at such a support level.

If Y_{17} = 0 in (6.12) then Y_{12} would equal the free market price Y_{12}^{*}. Thus equation (6.12) where Y_{17} = 0 can be substituted for Y_{12}^{*} in (6.11) to give (6.13).

$$(6.13)\quad Y_{17} = a_1 Z_{16} + a_1\, b_2\, Y_{21} - a_1 b_3\, Z_{41} + a_1 b_4 Z_{40} - a_1 b_5 Z_{26} + a_1 b_6 Y_{11}^{*} + u$$

This equation fitted by the LISE procedure yielded the following parameter estimates:

$$(6.14)\quad Y_{17} = -585.06 + \underset{(.180)}{.474}\, Y_{11}^{*} + \underset{(.151)}{.107}\, Y_{21} + \underset{(.211)}{.386}\, Z_{40} - \underset{(.304)}{.650}\, Z_{41} - \underset{(3.278)}{.603}\, Z_{26} + \underset{(1.252)}{2.799}\, Z_{16}$$

All parameter signs substantiated the hypothesis with the standard errors on most of the parameters being relatively small. A method of solving systems of equations is given in Chapter XII.

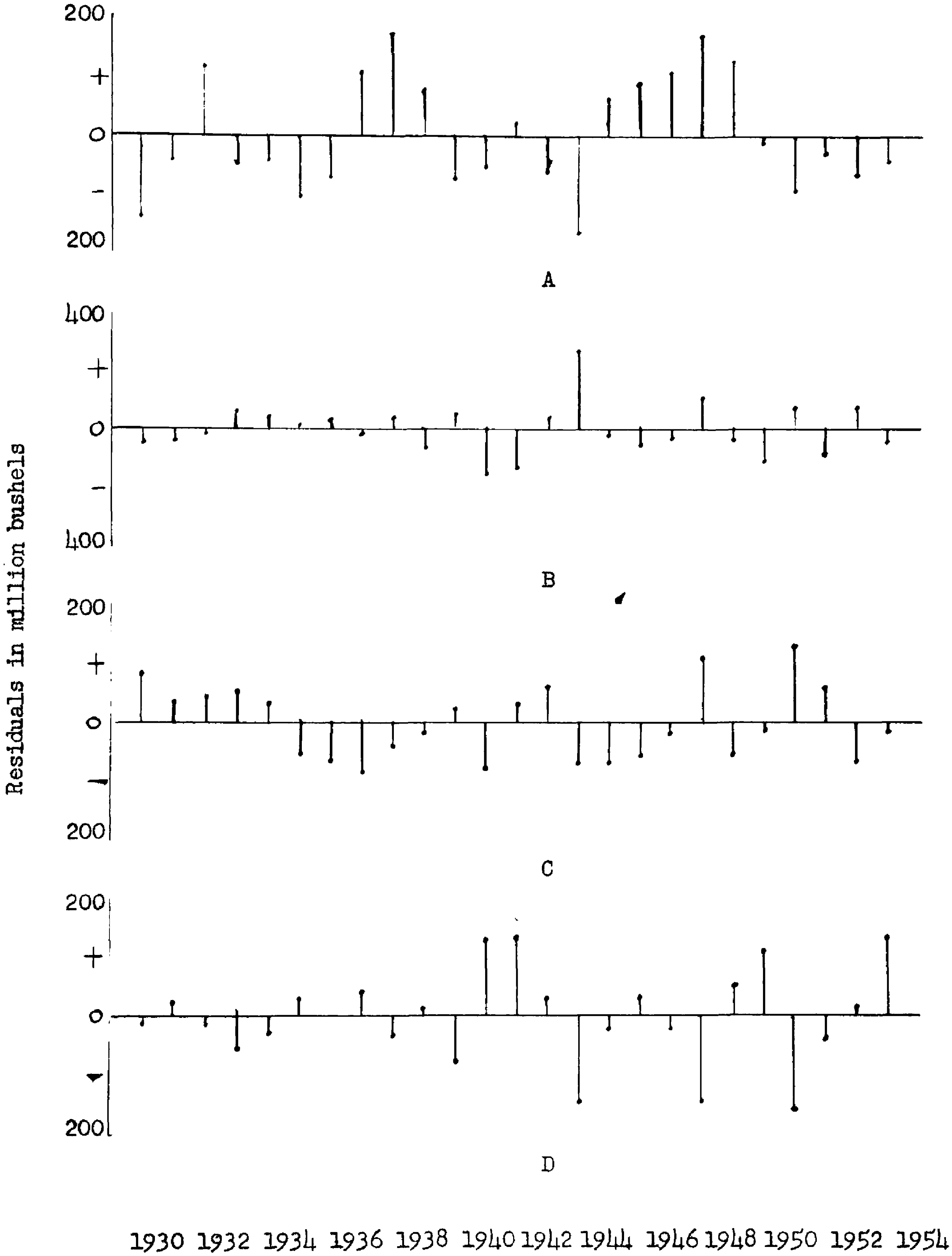

Fig. 7. Unexplained residuals for wheat model.

A. Production

B. Commercial demand

C. Inventory demand

D. Government demand

CHAPTER VII

SOYBEANS

During the last twenty years soybeans have increased in importance to become the fifth most valuable crop in the nation. Currently they rank second in the corn belt as a cash crop. This rapid expansion was the result of multiple forces triggered by depression production controls and World War II. Research in developing varieties which (1) were adapted to certain areas, (2) had a higher oil and protein content, (3) were not susceptible to lodging and (4) were amenable to mechanized harvesting had been started in the thirties. When World War II erupted, the increased demand for fats and oils coupled with the loss of imports set the stage for expanded production. From 1940-42 a five-million acre increase in soybeans for beans occurred—the most rapid on record—with two-fifths of this increase in acreage coming from a decline in soybeans used for forage and three-fifths acreage released from other crops.

Since soybeans are adaptable to climatic and soil requirements similar to corn, the distribution of production has centered in the corn belt. In addition much of the machinery is readily substitutable between the two crops. In fact, broadcast seeding has been largely abandoned in favor of row planting since corn planters and cultivators were already available when the rapid expansion in production occurred.

Supply Relationship

The above discussion[1] represents a background of material against which the changing structure of production may be viewed. The rapid increases in production occurred as a result of the profitability of raising soybeans as compared to alternative crops, and the technological advances in varieties, machinery and cultural practices. A recent survey[*] of several thousand soybean producers supports the belief that these are the main factors governing supply. The factors handicapping production for these producers were weather, weeds, low soil fertility, poor stands, low yields, no price inducement, insects, disease, lack of fertilizer response, poor cultural practices and losses at harvesting time.

While not all of these factors are directly measurable, the supply relationship constructed in the current effort includes most of these effects. Price inducement is measured by including the price per bushel received by farmers during the previous year. Factors dealing with the application of machinery to soybean production are measured by the inclusion of the number of row crop cultivators on farms. This number is estimated by taking an eight year moving average of manufacturers

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[1] A fairly complete discussion of the historical development is to be found in an article by: E. G. Strand, Soybeans In American Farming, United States Department of Agriculture, Bureau of Agricultural Economics, Technical Bulletin No. 966, November, 1948.

[*] Soybean News, published by National Soybean Crop Improvement Association, Decatur, Illinois, Vol. 7, No. 4, April 1956.

sales. For technological improvements in varieties and non-machinery cultural practices such as seed inoculation or pre-emergence spraying a linear time factor is included. Preliminary fits were made including both fertilizer prices and quantities used in the five leading soybean producing states as relevant variables, but no justifiable relationship could be determined. The influence of weather on production is measured by the inclusion of a specific variable—July rainfall in Illinois. This variable does not represent the complete effects of climatic conditions on production, but does appear to capture a large portion of such effects. It was accepted after the following variables or combinations of variables were tested,

A. average temperatures for the months of May, June and July at twelve specific points in the five major producing states.

B. average rainfall for the months of

(a) July
(b) August

for the states of

(1) Ohio
(2) Indiana
(3) Illinois
(4) Iowa
(5) Missouri

The final variable in the supply relationship is the acreage harvested for the preceding year. It is hypothesized that this variable along with the price inducement variable and the level of inputs available on the farm for production, determine the current acreage to be planted.

These variables were fitted in a least squares relationship since all variables except current production were judged to be predetermined. Standard errors of regression coefficients are given in parentheses.

$$(7.1)\quad Y_{s1} = -255.60 + .939\, Y_{s7-1} + .114\, Y_{s2-1} + 40.356\, Z_{s1} +$$

$$(7.1)\quad Y_{s1} = -255.60 + \underset{(.433)}{.939}\, Y_{s7-1} + \underset{(1.113)}{.114}\, Y_{s2-1} + \underset{(34.430)}{40.356}\, Z_{s1} + .390\, Z_{s3} + .607\, Z_{s4}$$

Y_{s1} = production of soybeans in hundred thousand bushels.

Y_{s7-1} = tens of thousand acres of soybeans harvested during the previous year.

Y_{s2-1} = price of soybeans during the previous year in cents per bushel.

Z_{s1} = time, 1929 = 0.

Z_{s3} = hundreds of row crop cultivators on farms.

Z_{s4} = average July rainfall for Illinois in hundredths of inches.

The signs of all regression coefficients are as hypothesized although the standard errors on some are large.

Demand Relationship

The demand for soybeans has undergone drastic changes during the time period studied in this analysis. In the early years processing was not important but by the late 1930's approximately 80 percent of the beans were being processed. Soybean oil and soybean oil meal are the two major products arising from processing. The crude oil is refined and is utilized mainly as an edible oil with small quantities being used in the paint and varnish trade. The meal is largely used as a protein supplement in livestock feeding though some is also used industrially.

The factors affecting the demand for these two primary products mainly determine the overall demand for soybeans. The approach followed is to study the separate demand curves for these two products before combining them into a single demand equation for soybeans. Given the production of soybeans for a year, the yield of oil and meal is determined by three factors: the percent of the crop sold for crushing, the oil content of the beans and the method of processing used. In this analysis, it is assumed that the oil content does not change over time due to varietal changes or climatic influences. As processors have substituted solvent extraction for mechanical processing the yield of oil per bushel has increased while that of meal has decreased.[1] Since oil sells for approximately three times as much per pound as does meal, the net effect is to increase the total value of a bushel of soybeans.

The uses of the two soybean products suggest the type of demand factors which affect the farm price of soybeans. The farm price is determined by what processors can receive for the oil plus the meal, less the margin they require for processing, transporting, other service, and profit as the product is moved into industry. Thus, for one bushel of soybeans, an identity equating the value of a bushel of soybeans and the value of oil plus meal less a margin can be stated.

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[1]For a more complete discussion see the article by: M. S. Simon, Soybeans, Economic Analysis Relating to Processing, United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., Marketing Research Report No. 35, May, 1953.

(7.2) $Y_{62} = Y_{63} + Y_{64} - Z_{27}$

Y_{62} = price received by farmers for soybeans, in cents per bushel.

Y_{63} = value of oil in one bushel of soybeans.

Y_{64} = value of meal in one bushel of soybeans.

Z_{27} = margin involved in moving one bushel of soybeans from the grower to the user of oil and meal.

Value of Soybean Oil

The value of the soybean oil which can be processed from one bushel of soybeans is associated with the yield of oil per bushel and the price of oil. The yield is said to change only as improved methods of extraction are developed and used. As a measure of this change in yield, the percent of oil extracted by the solvent method is used. Extrapolations were made for the first years for which recorded data are unavailable. This accounts for the improved methods of extraction but does not include yield changes due to the chemical composition of the beans as they are affected by changes in varieties and weather. The price of oil per bushel is associated with the price of competing oils, the amount crushed, per capita disposable income, and the general price level. Cottonseed oil is assumed to be the major competing oil. The wholesale price per pound of cottonseed oil is included as a measure of the competition present. It is hypothesized that an estimate of the percentage of production which will be crushed in a crop year can be made, based upon market observations during preceding years. Per capita disposable income and the general price level represent the same factors discussed in earlier sectors. The relationship considered is given in (7.3).

(7.3) $(Y_{83}, Y_{88} \ / \ Y_{93}', Z_{86}, Z_{41}, Z_{36}, u_{83})$

Y_{83} = value of oil per bushel of soybeans, in cents.

Y_{88} = amount of soybeans crushed, in hundred thousand bushels.

Y_{93}' = wholesale price of cottonseed oil, in cents per pound.

Z_{86} = percentage of oil extracted by the solvent method.

Z_{41} = per capita disposable income, in current dollars.

Z_{36} = price level with 1939=100.

u_{83} = random disturbance.

The LISE parameter estimates of this equation are given in (7.4), where Y_{83} is considered as the dependent factor.

$$(7.4) \quad Y_{83} = -27.123 + \underset{(0.33)}{.059} Z_{36} + \underset{(.005)}{.081} Y_{93}' - \underset{(.047}{.055} Z_{41} + \underset{(.013)}{.005} Y_{88} + \underset{(.215)}{.004} Z_{86}$$

It appears that cottonseed oil prices affect soybean oil prices substantially. On the other hand the method of extraction has had little effect on the value of oil per bushel, nor has the amount crushed. The latter effect may be a result of the rapid increase in demand for soybean oil which accompanied the production increases. Increases in both the income level and the price level act to increase the price of soybean oil.

Value of Soybean Oil Meal

The value of soybean oil meal per bushel of soybeans is mainly dependent upon the feed-livestock sector. Yields are again treated as for soybean oil with the development of solvent extraction methods decreasing the yield of meal per bushel. The price of meal is dependent upon the price of substitute products, the amount of soybeans crushed, the number of animal units to be fed and the general price level. As an indicator of the influence of competing products, the price per ton of crude cottonseed oil meal is included. The amount of beans crushed is the same as used above with a large supply supposedly causing lower prices for meal. The price of meal should be strengthened as the number of animal units to be fed increases since this is the major source of demand. The price level will also have a price raising effect. The relationship is given in (7.5).

(7.5) $(X_{84}\ X_{85},\ /\ X_{84}',\ Z_{85},\ Z_{25},\ Z_{26},\ u_{84})$

X_{84} = value of soybean oil meal per bushel of soybeans, in cents.

X_{85} = amount of soybeans crushed, in hundred thousand bushels.

X_{84}' = price of cottonseed oil meal (crude basis), in tens of cents per ton.

Z_{85} = percentage of oil extracted by the solvent method.

Z_{25} = number of animal units fed beginning October 1st.

Z_{26} = general price level, base 1939=100.

u_{84} = random disturbance.

The LISE parameter estimates for soybean oil meal are given in equation (7.6), where the normalization is carried out on Y_{s4}.

$$(7.6)\quad Y_{s4} = 64.207 + \underset{(.03)}{.031}\, Y_{s5} - \underset{(1.263)}{.219}\, Z_{s8} + \underset{(.005)}{.026}\, Z_{2s} + \underset{(.116)}{.144}\, Y_{s4}' - \underset{(.102)}{.041}\, Z_{2s}$$

The parameter signs on this equation were incorrect in the case of Y_{s5} and Z_{s8} as against those hypothesized. The reliability of the estimates can also be questioned in view of the estimated standard errors of the parameters.

<u>Prices Received by Farmers for Soybeans</u>

In estimating the farm price per bushel of soybeans only the three variables Y_{s2}, Y_{s3}, and Y_{s4} were used (7.7).

(7.7) $(Y_{s2},\ Y_{s3},\ Y_{s4},\ u_{s2})$

Y_{s2} = average price received by farmers for soybeans, in cents per bushel.

Y_{s3} = value of oil per bushel of soybeans, in cents.

Y_{s4} = value of soybean oil meal per bushel of soybeans, in cents.

u_{s2} = random disturbance.

The fitted relationship normalized on Y_{s2} is given in (7.8).

$$(7.8)\quad Y_{s2} = -.735 + \underset{(.239)}{.282}\, Y_{s3} + \underset{(.207)}{1.134}\, Y_{s4}$$

No satisfactory marketing cost index could be formed which was helpful in explaining farm price as dependent upon the manufacturer's price of oil and meal. In addition, the volume of exports was included as a determinant of price not included in the relationships covering meal and oil but again no significant relationship could be established.

Government price policies for soybeans were not considered in this analysis. While it is true that loans may have a stabilizing influence on market prices, in practically all years, loans on soybeans were redeemed leaving few soybeans in government stocks. The major exception up to 1953 occurred in 1948 when 10.6 million bushels were not redeemed by farmers. This amount was roughly equal to five percent of total production.

A solution to systems of equations is explained in Chapter XII.

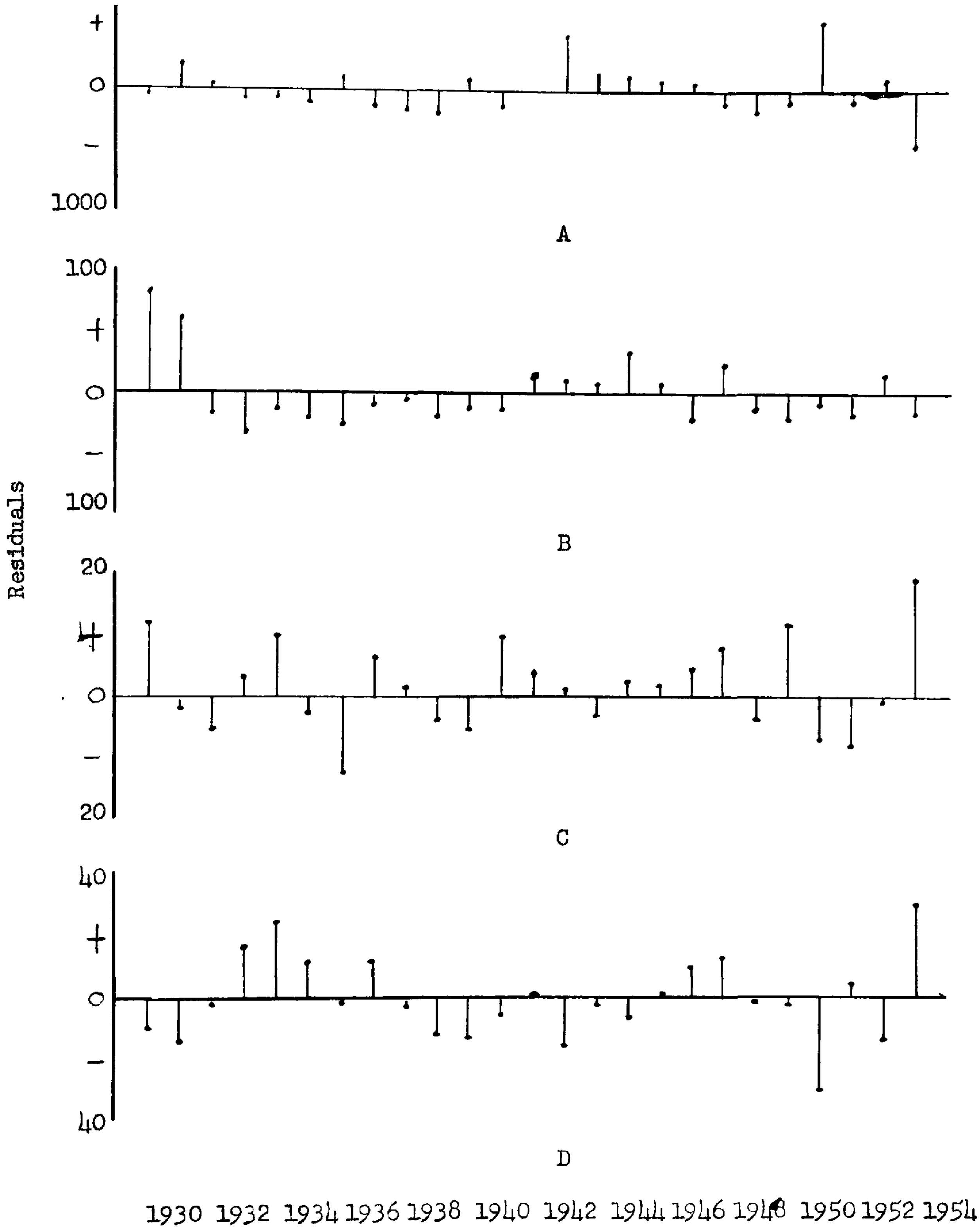

Fig. 8. Unexplained residuals for soybeans category.

A. Production - (hundred thousand bu.)

B. Price - (cents per bushel)

C. Demand soybean oil - (cents per bushel)

D. Demand soybean meal - (cents per bushel)

CHAPTER VIII

COTTON

Significant changes have occurred in cotton production and utilization during the time period covered in this study. Some of these changes are difficult to handle since they represent new or improved technologies and rapid structural changes due to wartime demands. Other changes have been more gradual and are more easily quantified.

Supply Relationship

During the past 25 years, national cotton production has been characterized by rather large acreage reductions with almost offsetting yield increases per acre. During the 1928-32 period, an average of 41.4 million acres yielded an average production of 14.7 million bales. This corresponds to the 1950-54 average of 23.8 million acres producing 14.1 million bales. While acreage has decreased in total, it has increased in specific areas. The irrigated areas of California, Arizona, and New Mexico, have become more important as producing areas in terms of both acreage and yield increases.

Factors which have contributed to increased yields, in addition to shifts in acreage to irrigated areas are the use of more and higher analysis fertilizers, better control of insect pests, improved weed controls, better selection of seed and improved stands of cotton.

In addition, the uncontrollable factor of weather greatly influences yields.

Shifts in acreage and production areas are mainly due to the relative profitability of cotton and alternative farm enterprises. Such profitability may be a result of technological changes, the availability and cost of farm labor especially at critical periods of time, the prices of cotton and alternative crops, the level of non-farm employment opportunities and the effect of governmental acreage allotment programs.

Production is measured in terms of running bales and includes all varieties. Acreage shifts and the trend towards more irrigation are included by selecting as a variable the percent of total acreage grown in California, New Mexico, and Arizona. The average amount of fertilizer applied to cotton per acre for the United States is included to measure the effect of fertilizer applications. The effect of insect pests and weather is measured by including the percentage reduction from "full yield" per acre due to insect pests and climatic factors. This variable represents an estimate of the average yield reduction due to deficient or excessive moisture, other climatic factors, plant disease, boll weevil and other insects in the states of Mississippi, Missouri, Virginia, North Carolina, South Carolina, Georgia, Florida, Tennessee, Arkansas, Texas, Alabama, Louisiana and Oklahoma. The profitability of producing cotton is influenced by the prices paid for items used in production and the price which producers expect to receive. Data for the prices paid index are averages for the Southern Piedmont, Mississippi Delta and Texas Black

Prairie Areas. Price expectations for cotton are represented by the higher of either the average price received by farmers during the preceding year or the announced support price. It is hypothesized that acreage changes occur slowly except when acreage allotments are imposed by government. The inclusion of such a structural change is attempted by using announced acreage allotments when they were in effect and the acreage in cultivation on July 1st of the preceding year when allotments were not in effect. Such a relationship including the above influences is given in (8.1).

(8.1) $(Y_{81}, Y_{82_{-1}}, Y_{87_{-1}}, Z_{81}, Z_{82}, Z_{83}, Z_{8,11}, u_{81})$

Y_{81} = production of cotton, in thousand running bales.

$Y_{82_{-1}}$ = higher of either the price received by farmers during the previous year for cotton or the announced support price per pound, in cents.

$Y_{87_{-1}}$ = announced acreage allotments where they were in effect and otherwise the acreage in cultivation on July 1st of the previous year, in tens of thousand of acres.

Z_{81} = the acreage grown in California, New Mexico and Arizona as a percentage of total acreage grown (total percent = 1000).

Z_{82} = yield decline due to weather and insects, as a percent of 1000.

Z_{83} = prices paid index for cotton farmers, as computed for farms in the South Piedmont, Mississippi Delta and Texas Black Prairie areas, 1947-49 = 100.

$Z_{8,11}$ = fertilizer applied per acre of cotton grown in the United States in pounds per acre.

$u_{8,1}$ = random disturbance.

The fitting of this relationship by a single equation least squares procedure yielded a negative parameter for $Z_{8,11}$ indicating that increased fertilizer applications reduced production. Since such a result is not compatible with the theoretical concept of supply and is probably due to the quality of the data, $Z_{8,11}$ was omitted. The revised supply function is given in (8.2).

$$(8.2) \quad Y_{81} = 10892.674 + \underset{(.5968)}{2.6217}\, Y_{87_{-1}} + \underset{(1.5724)}{2.3978}\, Y_{82} + \underset{(28.2990)}{71.2460}\, Z_{81} - \underset{(4.7872)}{20.5851}\, Z_{82} - \underset{(72.8280)}{87.7711}\, Z_{83}$$

$$\bar{R}^2 = .70$$

The remainder of the parameter signs support the original formulation.

Demand Relationships

The supply of domestic cotton available for utilization within an August to July crop year is production, plus beginning inventories. Such an identity may be represented as in (8.3).

$$(8.3) \quad Y_{81}^{*} = Y_{81} + Z_{86} + Z_{87}$$

Y_{81}^{*} = total supply of cotton, in thousand running bales.

Y_{81} = current production of cotton, in thousand running bales.

Z_{86} = beginning inventory of cotton not under CCC loan, in thousand running bales.

Z_{87} = beginning inventory of cotton under CCC loan, in thousand running bales.

It is also possible to construct a second identity (8.4) which shows how supply is utilized during the crop year. The identity is based on the quantities entering domestic mill consumption, government loan or purchase stocks, private storage stocks, and the export market.

(8.4) $Y_{81}^{*} = Y_{85} + Y_{86} + Y_{87} + Z_{84} + Z_{87_{+1}}$

Y_{81}^{*} = total supply of cotton, in thousand running bales.

Y_{85} = domestic mill consumption of cotton, in thousand running bales.

Y_{86} = ending inventory of cotton in private storage, in thousand running bales.

Y_{87} = amount of cotton entering government purchase programs and not redeemed, in thousand running bales

Z_{84} = net United States exports of cotton, in thousand running bales.

$Z_{87_{+1}}$ = ending inventory of cotton in CCC storage, in thousand running bales.

Of the five demand outlets, the first three (Y_{85}, Y_{86}, Y_{87}) are treated in detail by considering structural relationships for each one. While exports are very important as a demand component, the relevant factors involved do not lend themselves well to the present structural analysis. To deal adequately with cotton exports an analysis would have to treat in detail such factors as world production, inventories and prices, the dollar exchange quantities held by importing countries, as well as the policies adopted by the United States government agencies in disposing of surplus stocks of cotton. The present analysis is not comprehensive enough to deal with such a complex structure. An indication of the effect and variability of domestic policies on cotton exports is given by the following statements as taken from previous analyses.[1]

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[1] L. D. Howell, Cotton--Price Relationships and Outlets for American Cotton, United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., Tech. Bull. No. 755, January, 1941.

> In the 1938-39 season, with a reduction in available market supplies of American cotton....and by the witholding of a substantial volume off the market by means of governmental loans, exports of American cotton were reduced to about 3,300,000 bales, the smallest in more than fifty years....

> ....with an export subsidy for American cotton during the first part of the 1939-40 season which permitted American cotton to be offered in foreign markets at competititve prices, ...sales reported during the first half of the season for export amounted to about 6,000,000 bales.

For somewhat similar reasons the quantity of cotton held in CCC storage at the end of the crop year is treated as a predetermined variable. The disposal of government stocks has not followed a pattern consistent enough to be quantified through the use of available time series data.

The movement of cotton out of CCC stocks for export has varied with specific governmental programs. CCC disposal has occurred at both competitive world prices and as almost outright donations. On the other hand, the movement of CCC stocks into domestic channels has been governed legally by specifying that the disposal price shall be not less than the higher of (1) 105 percent of the current support price plus reasonable carrying charges, or (2) the market price as determined by CCC. Because of such institutional factors and lack of adequate data, this analysis has not dealt endogenously with change in annual supply due to the release of government owned stocks. To do so would require treating Z_{97} and $Z_{97_{+1}}$ as endogenous variables and constructing equations for each. In this analyses, Z_{97} is considered known while an independent estimate of $Z_{97_{+1}}$ is made for predictive purposes.

Commercial Demand

Commercial demand for cotton as treated in this study is "domestic mill consumption." This is the demand for cotton to be consumed in manufacturing products for the household, as apparel, and in industry. The first two uses, which account for roughly seventy-five percent of current utilization, vary with per capita consumer income. The amount used for industrial purposes is declining as the substitution of synthetic fibers for cotton occurs more rapidly in this sector than in household and apparel areas. Previous analysis of the demand for cotton at the mill level have been very penetrating. One of the foremost is that undertaken by Lowenstein and Simon.[a] In addition to population, income, cotton prices, and the use of synthetic fibers, their analysis considered factors affecting inventories. By going to a reduced form implicitly, they incorporated such factors into the demand for mill consumption by including as an independent variable the deviations from "normal" of the stock unfilled order ratio.

In the present analyses, the commercial demand for cotton is said to be associated with per capita disposable income Z_{41}, and the general price level Z_{36}, as used in previous product categories. In addition, the domestic production of synthetic fibers is included in an attempt to measure its influence (as a substitute) on mill consumption of

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[a] F. Lowenstein and M. Simon, "Analysis of Factors that Affect the Mill Consumption of Cotton in the United States," <u>Agricultural Economics Research</u>. Agricultural Marketing Service, United States Department of Agriculture, Washington, D. C., Vol. VI, No. 4, October, 1954.

cotton. The price received by farmers for cotton is assumed to bear an inverse relationship to demand. An attempt to measure the level of marketing costs on demand is made by including the marketing margin on forty-two manufactured cotton articles. Though data on the stock unfilled order ratios are not available for the time period studied, private stocks on August 1st were included, the hypothesis being that stocks partially meet current demand. The above factors are represented in symbolic form in relationship (8.5).

$$(8.5) \quad (Y_{85}, Y_{82} \;/\; Z_{36};\; Z_{41}, Z_{86}, Z_{49}, Z_{9,10};\; u_{85})$$

Y_{85} = domestic mill consumption of cotton, in thousand running bales.

Y_{82} = average price received by farmers for cotton, in tenths of cents per pound.

Z_{36} = index of the general price level for the United States, 1939 = 100.

Z_{41} = per capita disposable income, in current dollars.

Z_{86} = beginning inventory of cotton, exclusive of CCC, in thousand running bales.

Z_{49} = production of synthetic fibers in United States, in million pounds.

$Z_{9,10}$ = marketing margin on forty-two cotton articles, in cents.

u_{85} = random disturbance.

After formulating and fitting the above equation, it was observed in several alternative fits that the parameter estimated for $Z_{9,10}$ was always insignificant, probably because of a high intercorrelation between $Z_{9,10}$ and Z_{36}. Consequently this variable was omitted from the analysis. The parameter estimated for Z_{59} always appeared as a positive amount contrary to the hypothesis that synthetic fibers offer competition for cotton. Therefore the coefficient on Z_{59} is repressed in the commercial demand equation. While it is known that synthetic fibers and cotton are competitors in many markets, the upward increase in both does not permit a satisfactory statistical analysis to be made. When the two series are plotted on a scatter diagram, it is obvious that an inverse relationship exists between the consumption of the two products when short time periods are considered but that a positive relationship exists when the 1929-53 time period in total is observed.

Thus in separate analyses, the regression of synthetic fiber production on mill consumption of cotton was computed for the time periods 1941-49 and 1950-55. The average elasticity for the two periods is equal to -0.15. This compares with elasticities of from -0.09 to -0.12 computed in analyses by Lowenstein and Simon.[3]

The estimated LISE parameters for this relationship including only the first five variables is given in (8.6) where Y_{58} is normalized.

$$(8.6)\quad Y_{58} = 11387.8122 - \underset{(9.029)}{12.4459}\, Y_{52} + \underset{(.1619)}{.1118}\, Z_{59} + \underset{(3.9581)}{9.0137}\, Z_{41} - \underset{(2.9087)}{10.1693}\, Z_{58}$$

The sign on Z_{58} is opposite to that hypothesized and it is believed that if data were available and the ratio of stocks to unfilled orders was substituted for Z_{58} a more satisfactory structural equation would result. If manufacturers tend to maintain such a ratio at a fairly

[3] *Op. cit.*

constant level and orders increased, it is possible that "mill consumption" would increase even though stocks were also increasing.

Inventory Demand

Inventory demand in this analysis represents the amount of cotton that will be carried over on July 31st of the current crop year which begins August 1st. Such a quantity represents the net result of manufacturer's expectations concerning prices and supplies and the desire to maintain inventories that bear a relatively fixed ratio to current sales. Such expectations are continually changing and are not quantifiable except as they may be represented by past events. A somewhat simple inventory relation is constructed which hypothesizes that low average annual prices of cotton will increase the incentive to hold stocks, that increases in current supplies—production plus carryin—will mean an increase also in carry-over and that increases in supplies exclusive of the United States should decrease the need to carry over stocks if they represent an alternative source of supply for domestic or foreign importers.

Such a relationship is formulated in (8.7).

(8.7) $(Y_{86}, Y_{82}, Y_{81}^{*}/Z_{88}^{*}, u_{86})$

Y_{86} = ending inventory of cotton in private storage, in thousand running bales.

Y_{82} = average price received by farmers for cotton, in tenths of cents per pound.

Y_{81}^{*} = total supply of cotton, in thousand running bales.

Z_{e8}^{*} = supply of cotton exclusive of United States, in tens of thousand running bales.

u_{e8} = random disturbance.

The fitted relationship using an LISE approach yielded the parameter estimates given in (8.8).

$$(8.8)\quad Y_{e4} = 637.060 - \underset{(4.469)}{4.096}\, Y_{e8} + \underset{(.156)}{.295}\, Y_{e1}^{*} - \underset{(1.239)}{.393}\, Z_{e8}^{*}$$

While the parameter signs satisfy the hypothesis they are not significant at generally accepted levels of significance.

Government Demand

The same procedure is followed in this product category as in previous categories involving government demand. The amount of cotton placed under loan has a wide year to year variation with almost one-half of the 1934 crop being placed under loan while for other years very little cotton has been placed under government title. Government price support programs for cotton have been in effect every year from 1933 to date with the exception of 1936. It is more apparent in this case than in the previous categories that the support price for cotton acts as a floor for cotton prices. When the national average support price for all qualities and the average price received by farmers for all cotton are compared, there are very few years in which the former was greater than the latter.

The hypothesis is that the amount of cotton placed under loan varies directly with the difference between the average support price and what the free market price would be in the absence of government support programs. This formulation is given in equation (8.9).

$$(8.9)\quad Y_{97} = a_1\,[Z_{98} - Y_{92}^*] + u_{97}^*$$

Y_{97} = quantity of cotton placed under CCC loan, in thousand bales.

Y_{92}^* = free market price for cotton.

Z_{98} = national average support price for cotton, in tenths of cents per pound.

u_{97}^* = random disturbance.

Since Y_{92}^* would only exist in the absence of government supports it is not observable. It is estimated to be a function of the price determining market forces where the total supply is available for commercial and inventory demand only, i.e., $Y_{97} = 0$. This representation is given in relationships (8.10), where $b_1 = 0$ and where Y_{92}^* is normalized to permit observation of the hypothesized parameter signs.

$$(8.10)\quad Y_{92}^* = b_1\,Y_{97} - b_2\,Y_{91}^* - b_3\,Z_{96}^* + b_4\,Z_{36} + b_5\,Z_{41} - b_6\,Z_{99} + u_{92}^*$$

Thus substituting in (8.9), Y_{97} can be estimated as a function of observable variables, as in (8.11).

$$(8.11)\quad Y_{97} = a_1\,Z_{98} + a_1\,b_2\,Y_{91}^* + a_1\,b_3\,Z_{96}^* - a_1\,b_4\,Z_{36} - a_1\,b_5\,Z_{41} + a_1\,b_7\,Z_{99} + u_{97}$$

Y_{97} = quantity of cotton placed under CCC loan, in thousand bales.

Z_{98} = national average support price for cotton, in tenth of cents per pound.

Y_{91}^* = total supply of cotton, in thousand running bales.

Z_{98}^{*} = supply of cotton exclusive of United States, in tens of thousand running bales.

Z_{36} = index of general price level for United States, 1939 = 100.

Z_{41} = per capita disposable income, in dollars.

Z_{99} = production of synthetic fibers in United States, in million pounds.

u_{97} = linear combination of the random disturbances u_{97}^{*} and u_{98}^{*}.

The LISE parameter estimates are given in (8.12).

$$(8.12) \quad Y_{97} = -7020.9202 + \underset{(.1497)}{.6099}\, Y_{91}^{*} + \underset{(1.4245)}{1.5991}\, Z_{98}^{*} + \underset{(3.6014)}{1.3104}\, Z_{99} +$$

$$\underset{(12.7596)}{18.5764}\, Z_{98} + \underset{(4.9986)}{1.0789}\, Z_{41} - \underset{(4.0638)}{8.0317}\, Z_{36}$$

The parameter sign on Z_{41} is opposite to that theoretically expected and no logical explanation is apparent. In an alternative fit manufacturer's beginning inventories, Z_{96}, and a marketing margin for cotton products, $Z_{9,10}$, were included. They caused little change in the above parameter estimates, but the expected parameters on Z_{96} and $Z_{9,10}$ did not have the hypothesized signs.

A general solution for systems of equations is given in Chapter XII, followed by an example using one subsystem of the model.

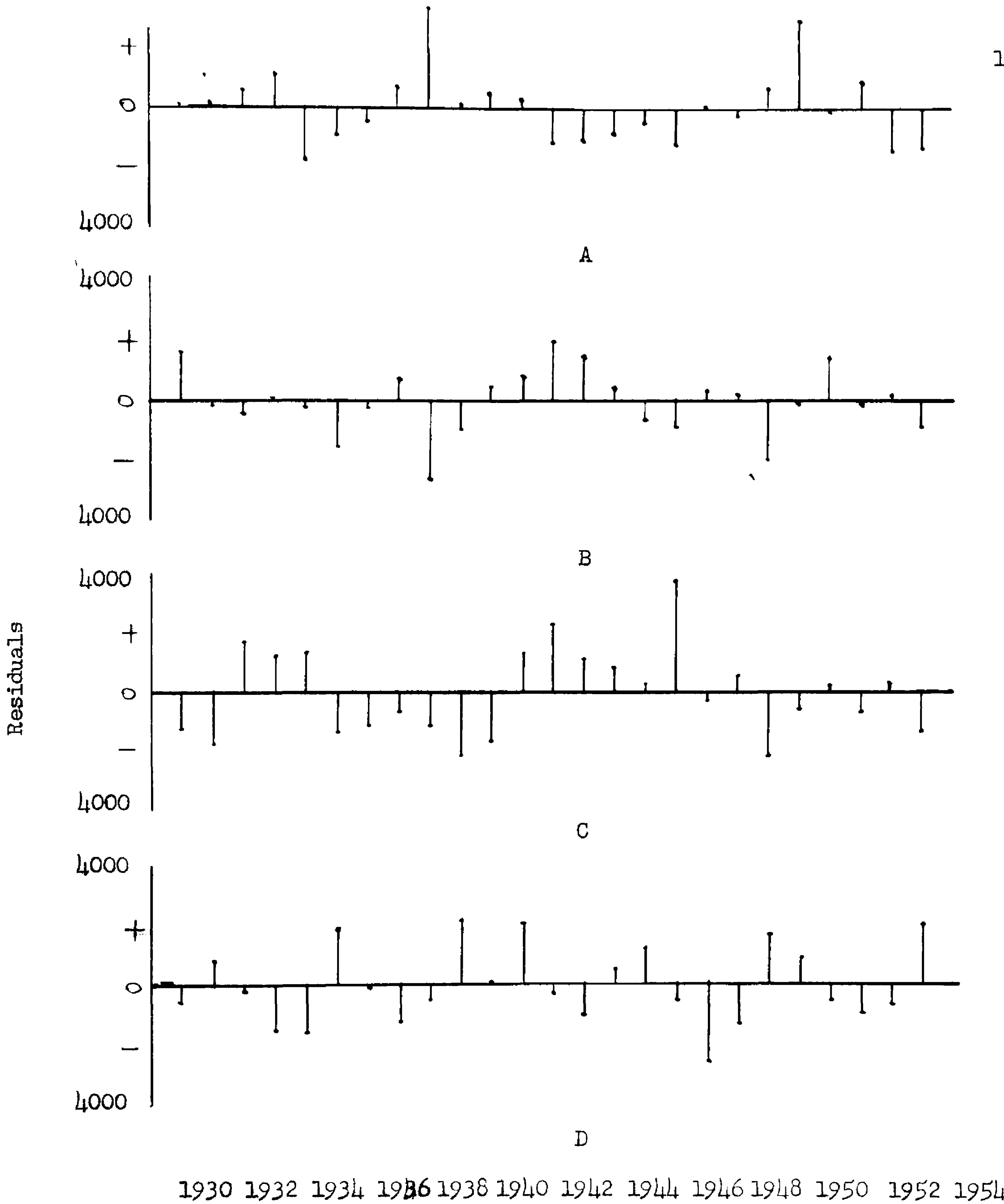

Fig. 9. Unexplained residuals for cotton category.

A. Production - (tens of thousand bales)

B. Mill consumption - (thousand bales)

C. Inventory demand - (thousand bales)

D. Government demand - (thousand bales)

CHAPTER IX

TOBACCO

The importance of tobacco as a farm product is easily substantiated in terms of value of production, as an exportable commodity, as a raw material for industry or as a source of income for some three quarters of a million farm producers. For the past few years, cash receipts from marketing tobacco have equaled approximately eight percent of the value of all crops marketed. Exports during this period equalled approximately twenty percent of domestic tobacco production and were surpassed in value only by wheat and cotton. Very little tobacco is imported although each year small amounts are received from Southeastern Europe and the Near East to be incorporated into American blends.

Tobacco production is centered in the Carolinas, Virginia, Kentucky and Tennessee although production is recorded annually in no less than twenty-one states. Within the major producing areas fairly specialized types of tobacco are grown, these types being distinguished by the cultural practices involved in their production and the end uses for which they are purchased. Because of the many types which have different characteristics of growth, quality and market utilization, it would be naive to assume that an analysis could be made which would handle adequately all the market forces acting upon tobacco as an aggregate. Therefore, in this analysis two subclasses have been handled in detail with separate structural relationships being constructed for each. These two subclasses represent flue cured (types 11-14) and burley (type 31).[1] For the period 1943-52, these types represented an average of 86 percent of the total production of tobacco. The analyses cover a July 1st crop year for flue cured and an October 1st crop year for burley. In both, it is assumed that no interrelationships exist between the two.

FLUE CURED TOBACCO

Supply Relationship

Flue cured tobacco is grown in the Piedmont area of Virginia and North Carolina, and in the Tidewater of North and South Carolina, Georgia, Florida and Alabama. The best quality of tobacco is grown on light, sandy, well drained soils having little organic matter. Such soils respond readily to fertilizer and rainfall. These factors, in turn, affect the quantity and quality of the leaf produced. In addition, the quality and quantity of leaf are influenced by the variety grown and the cultural practices followed. The size, shape and color of the cured leaf

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[1] Publications which give a fairly detailed treatment of tobacco in terms of trade, uses, production and markets are listed below.
W. H. Fisher, Economics of Flue Cured Tobacco, Research Department, Federal Reserve Bank of Richmond, Richmond, Virginia, January, 1945.
C. E. Gage, American Tobacco Types, Uses, and Markets, United States Department of Agriculture, Bulletin 249, 1942, rev. ed.
H. Geris, An Investigation Into Some Price-Determining Factors in American Tobacco Markets, North Holland Publishing Co., Amsterdam, Holland, September, 1954.
G. L. Johnson, Burley Tobacco Control Programs, Their Over-all Effect On Production and Prices, 1933-50. Kentucky Agricultural Experiment Station, University of Kentucky, Lexington, Kentucky, Bulletin, 580, February, 1952.

bear a rather direct relationship to the auction price of tobacco. Production is influenced by the type of fertilizer, time of topping and density of plants per acre. Care in harvesting, curing and grading are also controllable factors which govern both the amount and quality of the final product. This brief description of cultural practices emphasizes the high labor requirements of tobacco production. In addition the climatic conditions at the time of harvest are important as bright, clear days permit harvesting to proceed without damage to the quality and quantity of the crop.

The acreage of flue cured tobacco has shown little increase during the time period studied. The main reason for this is the acreage restricting programs which have been in effect every year since 1934 to date, except for 1939, in the form of acreage allotments or benefit payments. Such programs attempt to adjust production to demand. While acreage was restricted, yields and consequently production increased due to the responses to higher fertilization and other cultural improvements which were stimulated by stable support prices and favorable weather conditions. The fact that few, if any, profitable alternatives exist for tobacco-producing soil in some areas tends to prevent any great movement of land out of tobacco cultivation and may also result in overplanting allotments until sufficient penalties for doing so are invoked. Thus, it is suggested that the prices of alternative crops do not cause shifts in the production of flue cured tobacco and can therefore be ignored. Observation of the data, however, reveals that production appears to be responsive to tobacco prices during the previous season.

In the fitted production relationship, it is impossible to include all the factors discussed above as influencing supply. The total effect of climate is represented, though inadequately, by the rainfall during the month of June at Raleigh, North Carolina. It is believed that adverse weather conditions at the time of harvest will result in both lower production and quality. Improved cultural practices including fertilizers, varieties, insecticides, irrigation, etc. can only be included by hypothesizing that their adoption occurs in some proportion to the price received by farmers for tobacco during the preceding year. The major weakness of such an assumption is in assuming an irreversible demand curve for production inputs. For most inputs declining prices fail to cause a withdrawal although the rate of adoption may fall to zero. The effect of government allotment programs is represented by including the announced acreage allotments, or if they were not in effect, the acreage harvested for the previous year. The "least squares" estimates of the supply relationship are given as equation (9.1). The adjusted coefficient of multiple determination equals .80.

$$(9.1) \quad Y_{10,1} = 318.459 + \underset{(.187)}{1.589}\, Z_{10,4} + \underset{(.162)}{.228}\, Z_{10,2} - \underset{(.113)}{.207}\, Z_{10,7}$$

$Y_{10,1}$ = production of flue cured tobacco, in million pounds.

$Z_{10,1}$ = announced acreage allotments, or acreage harvested during the preceding year if allotments are not effect, in thousand acres.

$Z_{10,4}$ = the higher of, the support price announced for the current year or the actual price received during the previous year, in tenths of cents per pound.

$Z_{10,7}$ = average rainfall for the month of June in Raleigh, North Carolina, in hundredth of inches.

Demand Relationships

The current crop of tobacco is treated by the farmer as a perishable commodity, due to the need for redrying and storing the tobacco shortly after harvest is completed. Because this is an expensive, large scale operation, the farmer must dispose of his crop. Tobacco thus stored by a marketing cooperative, warehouseman or manufacturer is permitted to age two or more years to achieve a mellow flavor. This means that the trade must carry stocks equal to roughly three times current manufactures. Current farm marketings can be expected to equal roughly current manufactures plus or minus the anticipated change in manufactures three years hence. Such large stocks probably encourage speculation by marketing agencies and manufacturers, with stocks being increased when current prices are below expected future prices and purchases declining when prices are expected to fall.

The organization of the auction market for tobacco is instrumental in influencing tobacco prices. Aside from government support prices, which provide a minimum level, the price is maintained through the competitive bidding of buyers. However, when stocks have been adjusted to current and future needs, prices may fall if large quantities of tobacco remain unsold. Foreign buyers may be expected to bid on such quantities and, at the present time, it may be placed under government loan.

Thus three important demand sources are to be found for tobacco, namely, commercial demand as represented by manufacturers, government demand or the amount placed under loan and export demand. To adequately describe these demand outlets, it is necessary to break down current production into the amounts that flow into each of these uses. The same is necessary for beginning inventories. The data, however, are not complete enough for such accounting identities to be formed. One alternative is to treat the quantity of tobacco which disappears domestically as commercial demand. The disadvantage of this construction is the problem of accounting satisfactorily for the proportion of stocks versus current production moving into manufactured products. There is also the need to estimate ending inventories for manufacturers and the government, since these quantities must be known in order to estimate current domestic disappearance. The approach used is to treat the total quantity demanded as equal to current production and consider as demand outlets the amounts going into government storage and moving into domestic plus export markets. Such an identity is given in (9.2).

(9.2) $Y_{10,1} = Y_{10,4} + Y_{10,e}$

$Y_{10,1}$ = production of flue cured tobacco, in million pounds.

$Y_{10,4}$ = quantity of flue cured tobacco placed under loan in million pounds.

$Y_{10,e}$ = quantity of flue cured tobacco used commercially in domestic and export markets, in million pounds.

$Y_{10,e}$ is computed as the residual since the amount going under loan and the quantity produced are observable. However, these quantities,

$Y_{10,c}$ and $Y_{10,4}$ are treated as being determined simultaneously in the market.

Commercial Demand

As stated in the previous section $Y_{10,c}$, commercial demand, is the quantity of current production which is purchased by manufacturers or foreign buyers without having entered government loan programs. Since an ageing process is required in manufacturing, this represents the demand which manufacturers have for tobacco to be processed at a future date. If manufacturers maintain a given stock/sales ratio the demand will be closely related to current manufactures. This demand will be partially determined by the level of manufacturers' stocks in relation to sales as well as the price of tobacco on the auction market and current consumer demand as represented by per capita income. Any change in consumer demand due to changing tastes is said to be measurable by including a linear time trend.

A demand relationship including these factors is given as (9.3).

(9.3) $(Y_{10,c};\ Y_{10,a}/Z_{41};\ Z_{10,c};\ Z_{10,12};\ u_{10,c})$

$Y_{10,c}$ = commercial demand for flue cured tobacco, in million pounds.

$Y_{10,a}$ = average price received by farmers for flue cured tobacco in tenths of cents per pound.

Z_{41} = per capita disposable income, in current dollars.

$Z_{10,c}$ = time trend, 1929=1.

$Z_{10,12}$ = manufacturers' stocks/disappearance ratio.

$u_{10,c}$ = random disturbance.

The LISE estimates of this relationship are given in (9.4) where $Y_{10,e}$ is normalized.

$$(9.4) \quad Y_{10,e} = 2451.7934 - \underset{(12.833)}{15.0244}\, Y_{10,a} + \underset{(2.0988)}{2.6116}\, Z_{41} - \underset{(4.3608)}{5.2318}\, Z_{10;12} + \underset{(154.0535)}{173.3817}\, Z_{10,e}$$

All parameters have the expected signs although the statistical level of significance for each is not high.

Government Demand

While governmental policies restricted acreage and may have enhanced prices during the early thirties, it was not until 1939 that sizable quantities of flue cured tobacco were purchased by government agencies. The large crop of 1939 and the withdrawal of foreign buyers from the market due to World War II conditions caused a serious depressing of flue cured tobacco prices. The CCC entered the market at this time to replace foreign demand and continued to purchase tobacco under Lend-lease arrangements through the 1943-44 crop year. In addition to such purchases, loans were offered to producers beginning in 1941 which were effective in setting minimum prices for tobacco. Such action gave producers an alternative outlet for their tobacco when prices dropped to the support level.

It is hypothesized that the amount of tobacco placed under loan will increase directly as the difference between the average support price and the "free" market equilibrium price increases. The "free" market price is that price which would exist if no loans were made

and current production was placed upon the market for utilization.[a]
Relationship (9.5) describes the market demand for government.

$$(9.5)\quad Y_{10,4} = a_1 (Z_{10,3} - Y_{10,2}^*) + u_{10,4}^*$$

$Y_{10,4}$ = quantity of flue cured tobacco placed under loan, in million pounds.

$Z_{10,3}$ = national average support price for flue cured tobacco, in tenths of cents per pound.

$Y_{10,2}^*$ = "free" market equilibrium price for flue cured tobacco.

Since $Y_{10,2}^*$ is non-observable but could be approximated from price relationships where no loans are made, the factors determining $Y_{10,2}^*$ are specified in relationship (9.6). $Y_{10,2}^*$ is normalized to permit the hypothetical signs on the parameters to be shown.

$$(9.6)\quad Y_{10,2}^* = 0\, Y_{10,4} - b_1 Y_{10,1} - b_2 Z_{10,12} + b_3 Z_{41} + b_4 Z_{26} + u_{10,2}^*$$

Substituting for $Y_{10,2}^*$ in (9.5) gives (9.7).

$$(9.7)\quad Y_{10,4} = a_1 Z_{10,3} + a_1 b_1 Y_{10,1} + a_1 b_2 Z_{10,12} - a_1 b_3 Z_{41} - a_1 b_4 Z_{26} + u_{10,4}$$

$Y_{10,4}$ = quantity of flue cured tobacco placed under loan in million pounds.

$Z_{10,3}$ = support price for flue cured tobacco, in tenths of cents per pound.

$Y_{10,1}$ = current production of flue cured tobacco, in million pounds.

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[a]In addition to current production, supply may be increased by the release of government stocks. Such stocks may be considered as a different commodity due to the increase in value which accompanies storage. Thus government stocks may be purchased by manufacturers in lieu of current production when the price is sufficiently above the support level to permit legal release of stocks.

$Z_{10,12}$ = manufacturer's stocks: disappearance ratio.

Z_{41} = per capita personal disposable income, in dollars.

Z_{28} = index of general price level, 1939 = 100.

$u_{10,4}$ = random variables, being a linear combination of $u_{10,2}^{*}$ and $u_{10,4}^{*}$

The LISE estimates of these parameters where $Y_{10,4}$ is treated as the dependent variable are given in (9.8).

$$(9.8) \quad Y_{10,4} = 2750 - \underset{(2.311)}{3.561}\, Y_{10,1} + \underset{(5.940)}{2.039}\, Z_{10,2} + \underset{(2.590)}{1.066}\, Z_{10,12} +$$

$$\underset{(3.410}{8.509}\, Z_{41} - \underset{(2.396)}{5.823}\, Z_{28}$$

This structural equation is expressed merely to close the system since little value may be attached to the estimated parameters. The signs on $Y_{10,1}$ and Z_{41} are opposite to that expected and the large standard errors make the parameters significant at very low probability levels. The reasons for such results are only a matter of conjecture and may include, aside from data and functional form problems some of the following: The fact that tobacco is stored to acquire increased quality may cause buyers to let tobacco go into government stocks to be purchased at a later date when the quality has been improved. In addition, the export market for flue cured tobacco is very important and this market may be almost completely controlled by institutional arrangements as was the case under the Lend-Lease program. If this is the case, the economic structure as depicted in this model is very inappropriate. In addition, recent technological developments in the cigarette making industry

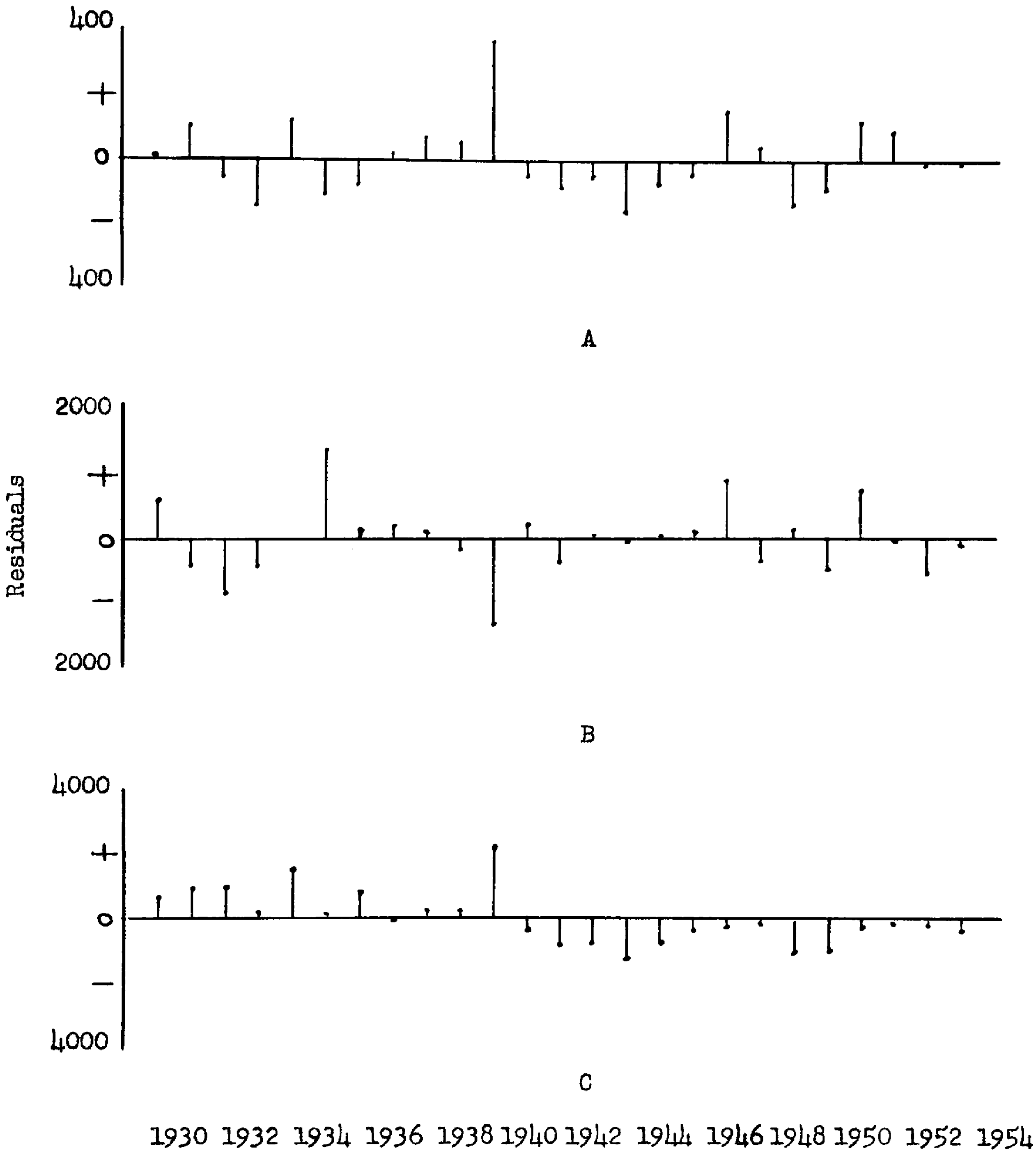

Fig. 10. Unexplained residuals for flue-cured tobacco category.

A. Production - (million pounds)

B. Commercial demand - (million pounds)

C. Government demand - (million pounds)

covering blending, and use of low grade tobaccos may have introduced enough structural change to render inappropriate the analysis contained in this model. A method of solving a model is outlined in Chapter XII.

BURLEY TOBACCO

Supply Relationship

The central area for burley production is the state of Kentucky with lesser amounts being grown in all adjacent states. Total production approximately doubled during the time period involved in this study. Production increases have occurred with little increase in acreage but largely as a result of increases in yield per acre. However, year-to-year production variations are a result of both acreage and yield changes. The acreage of burley produced is determined by both economic and institutional forces. Since 1934, except for 1939, governmental restrictions on acreage have been imposed, either in the form of direct allotments or payments to farmers who reduced their planted acreage. Even though such restrictions as allotments are imposed, the resulting acreage is determined by the economic forces which determine whether or not the allotted acreage shall be exceeded or underplanted. Such forces include the expected profitability of producing burley as compared to alternative crops and the physical facilities available for handling the produced crop. As the expected price for burley increases absolutely and relative to prices of alternative crops, acreage may be expanded to the level at which penalties for overplanting become a sufficient deterrent.

Wage rates and the cost of other items used in producing burley will also affect production inversely. Since burley is air-cured by hanging it in drying barns for a lengthy period of time the available storage space will provide somewhat of a maximum to increased production for short time periods. Johnson[a] has regarded such factors in completing a statistical analysis of underplantings with limited success. In the present analysis the structure generating such underplantings is not dealt with explicitly. The analyses attempt to consider total production as a function of announced allotments (or the previous year's acreage if allotments are not in effect) and those measurable factors which govern yield. Some of the above factors influence yield as well as underplantings in the same direction and therefore a certain part of the underplanting model is dealt with in the total supply relationship.

As indicated previously yield increases have been noticeable over the past twenty-five years and, in fact, have been fairly constant in nature. Johnson[*] lists (1) soil treatment both before and after plants are set, (2) selection of varieties, (3) handling (including labor practices) of the growing and maturing plants, (4) quality of land used, and (5) weather as the major factors determining yields. It is not possible to aggregate such factors into suitable quantitative indexes and therefore they are said to be measurable only as they are related to observable economic data. In this analysis, the price received for

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[a] _Op. cit._

[*] _Ibid._

burley during the previous year is said to be associated with the first four factors. Since yield increases have shown some consistency for the time period involved, a linear time trend is included to capture some of the effect of the continuous adoption of improved varieties, production and handling techniques. The above factors are thus incorporated into the behavioral supply relationship given in (9.9) which is estimated using a "least squares" technique.

(9.9) $(Y_{11,1}, Y_{11,2_{-1}}, Z_{11,2}, Z_{10,6}, u_{11,1})$

$Y_{11,1}$ = production of burley tobacco, in million pounds.

$Y_{11,2_{-1}}$ = average price received by farmers for burley during the previous year, in tenths of cents per pound.

$Z_{11,2}$ = acreage allotments if in effect, otherwise previous years acreage, in thousands.

$Z_{10,6}$ = time trend, 1929 = 1.

$u_{11,1}$ = random disturbance.

The fitted relationship appears in (9.10) with the estimated standard errors appearing in parentheses.

$$(9.10)\quad Y_{11,1} = -12.260 + \underset{(.047)}{.529}\, Y_{11,2_{-1}} + \underset{(.029)}{3.189}\, Z_{10,6} + \underset{(.014)}{.548}\, Z_{11,2}$$

$$\bar{R}^2 = .83$$

<u>Demand Relationships</u>

The auction market remains open from early December to February. During this time growers dispose of their tobacco. The market behavior of producers is largely governed by the two alternative outlets for their tobacco—commercial companies or grower associations operating on governmental account. Auction bids determine the market price and if this price fails to exceed the loan rate the grower may pledge it for loan which action also helps determine what the market price shall be.

Commercial Demand

Burley tobacco, like flue cured, must be aged before it is consumed and this results in the holding of large stocks by the trade. Assuming that manufacturers try to maintain a stock/sales ratio, their current demands will equal current manufactures plus or minus changes in anticipated manufactures two or three years hence. It could well be hypothesized that the influence of current stocks on current demand by manufacturers may not be great since the tobacco in stock is not a complete substitute for the current crop. It is believed current prices do exert some influence over manufacturer's demands although one would expect such a price elasticity to be small since the price of the leaf is a relatively small part of the total inputs involved in the production of final tobacco products. In addition to tobacco prices, buyer's purchases will increase as per capita disposable income increases since tobacco products are assumed to have a positive income elasticity of demand. Changes in consumer tastes or increase in the percentage of smokers is said to be measurable with the inclusion of a linear time trend.

While domestic disappearance is usually related to the above factors in a dependent sense, it is not used in this analysis. Instead, commercial demand has been computed as the difference between current production and the amount placed under loan and this may exceed or be less than domestic disappearance depending upon how manufacturer's adjust their stocks. The relationship involving the above relevant variables is given in (9.11).

$$(9.11) \quad (Y_{11,3},\ Y_{11,2}\ /\ Z_{11,12},\ Z_{41},\ Z_{38},\ Z_{10,e},\ u_{11,3})$$

$Y_{11,3}$ = quantity of burley purchased by manufacturers in million pounds.

$Y_{11,2}$ = average price received by farmers for burley tobacco, in tenths of cents per pound.

$Z_{11,12}$ = manufacturers stocks: disappearance ratio.

Z_{41} = per capita personal disposable income in dollars.

$Z_{10,e}$ = linear time trend, 1929 = 1.

$u_{11,3}$ = random disturbance.

The LISE parameter estimates for relationship (9.11) are given in (9.12) where $Y_{11,3}$ is normalized and the standard errors of the parameters are given in parentheses.

$$(9.12) \quad Y_{11,3} = 765.698 - \underset{(.5067)}{1.6735}\, Y_{11,2} + \underset{(.1475)}{.3602}\, Z_{41} - \underset{(.6116)}{2.0109}\, Z_{11,12} +$$

$$(9.12) \quad Y_{11,3} = 765.698 - \underset{(.5067)}{1.6735}\, Y_{11,2} + \underset{(.1475)}{.3602}\, Z_{41} - \underset{(.6116)}{2.0109}\, Z_{11,12} +$$

The structural parameters support the formulation hypothesis for commercial demand and are reliable at generally accepted significance levels.

Government Demand

As indicated above, growers have the choice of pledging their tobacco to grower associations for non-recourse loans if the auction price does not compare favorably in their estimation with the support price. It is hypothesized in this section that the amount of tobacco which will go to the grower associations is a function of the difference between the support price and what the "free" market price would be in the absence of government intervention, i.e. government demand equals zero. Such a functional relationship is exhibited in (9.13).

(9.13) $Y_{11,4} = a_1 (Z_{11,2} - Y_{11,2}^*) + u_{11,4}^*$

$Y_{11,4}$ = quantity of burley tobacco pledged for loans, in million pounds.

$Z_{11,2}$ = national average support price for burley tobacco, in tenths of cents per pound.

$Y_{11,2}^*$ = market price for burley which would exist in the absence of government support programs.

$u_{11,4}^*$ = random disturbance.

The "free" market price is nonobservable but is assumed to be a function of observable market variables which are substituted for $Y_{11,2}^*$. Such a function is given in (9.14) with the hypothesized parameter signs.

(9.14) $Y_{11,2}^* = 0Y_{11,4} + b_2 Z_{41} - b_4 Z_{11,12} - b_3 Y_{11,1} + u_{11,2}^*$

When these values are substituted in (9.13) the resulting equation is as follows:

(9.15) $Y_{11,4} = a_1 Z_{11,2} - a_1 b_2 Z_{41} + a_1 b_4 Z_{11,12} + a_1 b_3 Y_{11,1} + u_{11,4}$

$Y_{11,4}$ = quantity of burley tobacco pledged for loans, in million pounds.

$Z_{11,2}$ = national average support price for burley in tenths of cents per pound.

Z_{41} = per capita personal disposable income, in dollars.

$Z_{11,12}$ = manufacturer's ratio of stocks to disappearance.

$Y_{11,1}$ = current burley production, in million pounds.

$u_{11,4}$ = random disturbance being a linear combination of $u_{11,4}^*$ and $u_{11,2}^*$.

The LISE results of this fitted relationship are given in (9.16).

$$(9.16) \quad Y_{11,4} = -314.265 + \underset{(.1288)}{.7914}\, Y_{11,1} - \underset{(.0726)}{.1987}\, Z_{41} + \underset{(.1984)}{.6100}\, Z_{11,12} + \underset{(.1461)}{.1832}\, Z_{11,2}$$

The structural relation indicates that increases in current production, the support price and the ratio of manufacturers stocks to disappearance all serve to increase significantly the amount of tobacco going under loan. Increases in consumer demand as represented by per capita disposable income act as a deterrent to placing tobacco under government loan.

A solution to linear systems of equations is described in Chapter XII.

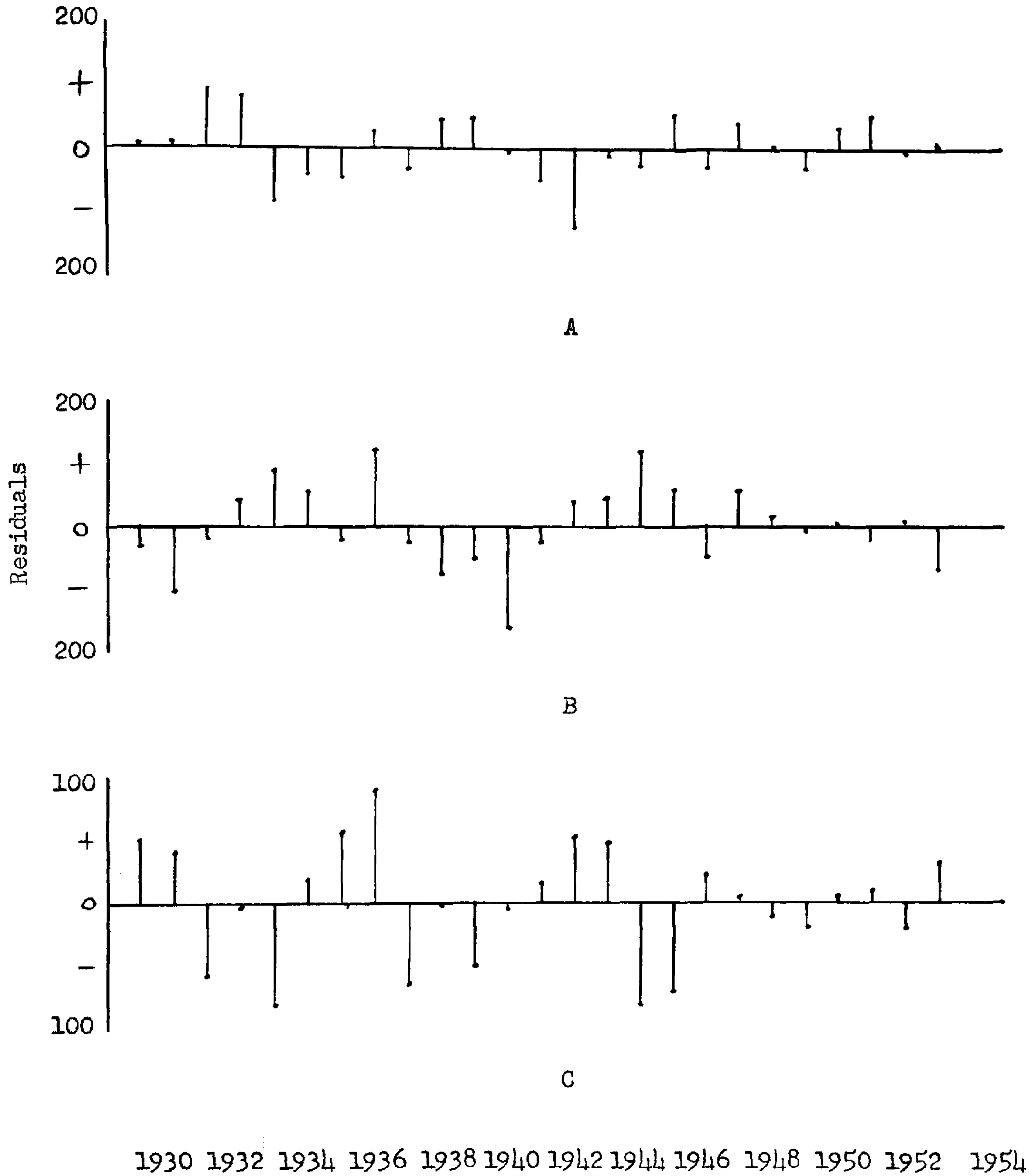

Fig. 11. Unexplained residuals for burley tobacco.

A. Production - (million pounds)

B. Commercial demand - (million pounds)

C. Government demand - (million pounds)

CHAPTER X

VEGETABLES

Problems of aggregation have beset economists for generations. This product category exhibits some of these problems acutely. It is impossible to construct econometric models for each major vegetable or truck crop. Even for a single product, several supply curves often exist due to the seasonality of production. Similarly, no completely satisfactory method of aggregating vegetables into groups containing a satisfactory degree of homogeneity is available. Yet it is possible to consider vegetables as a somewhat separate entity in the consumer's diet and in production. This study treats all vegetables as one commodity except that separate analyses are considered for processed vegetables as compared to those consumed in a fresh form. This procedure completely ignores the existence of substitution and complementarity between vegetables. Further, since the analyses are completed using a "single equation" approach no account is taken of substitution between the processed and fresh forms.

PROCESSED VEGETABLES

The processing of vegetables assumes increasing importance as new methods of preservation are adopted. In particular, the process of freezing vegetables has been widely adopted and is one of the reasons for the increased production and consumption of processed vegetables. Commercial processing as considered in this product category covers production for commercial canning, freezing, pickling and other processing exclusive of dehydration which is included as a fresh product.

A calendar year is considered and the following vegetables are included in the processing category—asparagus, lima beans, snap beans, beets, cabbage for sauerkraut, sweet corn, cucumbers for pickles, green peas, pimentos, spinach and tomatoes. The production of these crops is equal to the sum of the tonnage produced for each. Similarly the value of production is the sum of the individual crop values. The value figures are then deflated by the production figures by years to give a "value per ton" figure which is considered to be the price for vegetables. The production figures represent the quantities of the raw products procured by commercial processors either through grower contracts, grown by processors or purchases on the open market. Consumption is assumed to be equal to production which implies that the variation in stocks of processed vegetables are negligible.

Supply Relationship

A simple behavioral supply relationship is constructed for considering processed vegetables. Production is dependent upon the price received and the acreage harvested, during the previous year. In addition, current prices were included as an independent variable but the estimates showed considerable improvement when they were omitted.

A single equation, least squares regression was computed and the results are given in (10.1), with the standard errors of the parameters in parentheses.

$$(10.1) \quad Y_{13,1} = 46.120 + \underset{(2.600)}{6.991}\, Y_{13,2-1} + \underset{(.755)}{1.693}\, Z_{13,1}$$

$$\bar{R}^2 = .71$$

$Y_{13,1}$ = production of commercial vegetables for processing in thousand tons.

$Y_{13,2-1}$ = value per ton of vegetables for processing during the previous year, in tenths of dollars per ton.

$Z_{13,1}$ = acreage harvested of vegetables for processing during the previous year, in thousands.

<u>Demand Relationship</u>

For the vegetables considered in this category, consumption has been increasing consistently during the time period under study. Such vegetables are hypothesized to have a positive income elasticity of demand and a negative price elasticity. The marketing cost index, Z_{40}, is also included as a measure of the differences in retail and farm prices. Since only one demand outlet is considered the regression is computed in the form of a price determination equation. The relationship fitted with a least squares procedure is given in (10.2), with the standard errors of the regression parameters in parentheses.

$$(10.2) \quad Y_{13,2} = 46.793 + \underset{(.0495)}{.4835}\, Z_{41} - \underset{(.0070)}{.01071}\, Y_{13,1} - \underset{(.0281)}{.1341}\, Z_{40}$$

The adjusted coefficient of multiple determination is equal to .97.

$Y_{13,2}$ = value per ton of vegetables for processing, in tenths of dollars per ton.

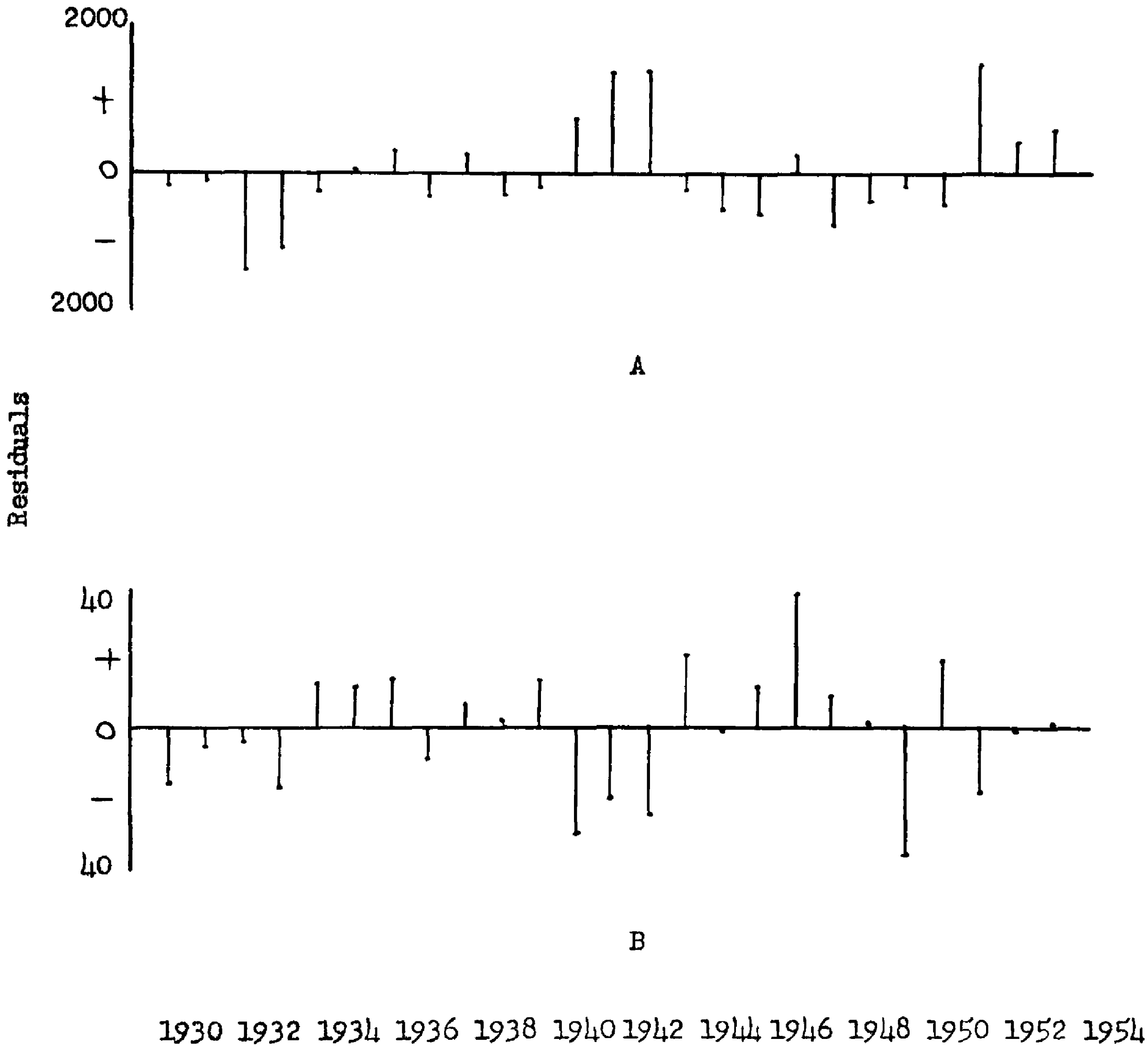

Fig. 12. Unexplained residuals for processing vegetables.

A. Production - (thousand tons)

B. Price - (tenths of dollars per ton)

$Y_{12,1}$ = production of commercial vegetables for processing, in thousand tons.

Z_{41} = per capita disposable income, in dollars.

Z_{49} = index of hourly marketing cost for food.

The parameter estimates show a surprisingly good fit in relation to their standard errors. In addition the percent of variance left unexplained is quite small. Were data on canners stocks available for the complete time period a more complete relationship could be established by their inclusion.

FRESH VEGETABLES

The aggregate supplies of fresh vegetables represent the amounts that will be available for harvest during the year. This includes the acreage harvested plus the acreage partially harvested or not harvested due to low prices or other economic factors. It is unfortunate that completely consistent series on acreage, production, and value are not available. The series have been revised, but revised estimates for only 1939-53 are available. In addition, the original data are not available for the years 1952-53. The revisions consisted of including commercial production, as in the original series, plus local market production in areas near consuming centers. An indication of the discrepancy involved is shown in data for 1939 when the revision occurred, and where both series are available. Under the revised series, as compared to the original, acreage increased eight percent and production increased seven percent.

Supply Relationship

The total supply of fresh vegetables in this analysis is equivalent to the simple sum of the tons produced of the following crops: artichokes, asparagus, lima beans, snap beans, beets, broccoli, Brussel sprouts, cabbage, cantaloupes, carrots, cauliflower, celery, sweet corn, cucumbers, egg plant, escarole, garlic, melons, kale, lettuce, onions, green peas, green peppers, shallots, spinach, and tomatoes. Such vegetables are widely grown within the United States and in many cases have more than one seasonal production period. A more complete analysis would treat these vegetables individually and also by production periods.

In this analysis, a simple supply equation, similar to that used for the processing category, is constructed. Producers are said to respond to prices received during the previous year. In addition, the acreage produced is associated with the acreage harvested during the previous year. As in the previous case, current price was included but turned out to be non-significant, having in fact a negative sign on the regression coefficient when production was chosen as the dependent variable. The relationship fitted by a least squares procedure is given in (10.3) with the standard errors of the parameters appearing in parentheses.

$$(10.3) \qquad Y_{12,t} = 605.543 + \underset{(.497)}{4.796}\, Y_{12,t-1} + \underset{(.422)}{2.546}\, Z_{12,t}$$

The adjusted coefficient of multiple determination is equal to .93.

$Y_{12,t}$ = production of fresh vegetables, in thousand tons.

$Y_{12,s-1}$ = value per ton of fresh vegetables, for the preceding year, in tenths of dollars.

$Z_{12,1}$ = acreage harvested of fresh vegetables, for the preceding year, in thousand acres.

<u>Demand Relationship</u>

Since this product category represents products which are very perishable in nature the demand for storage is not of any significance. Likewise, demand for processing is treated independently to leave only commercial demand by consumers for the fresh product. Once again production and consumption are assumed to be equal although the amount of wastage and the overestimation of production when low prices discourage harvesting are both causes of difference between the two figures.

Consumption of fresh vegetables has followed a rather consistent increase which can be attributed largely to real income and population increases. The relationship under consideration is constructed in an attempt to determine the current farm price which is said to be influenced by production, income, and an index of marketing costs. The fitted relationship appears in (10.4) with the standard errors of the regression parameters appearing in parentheses.

$$(10.4) \quad Y_{12,s} = 235.345 + \underset{(.135)}{1.010}\, Z_{41} - \underset{(.245)}{.0395}\, Y_{12,1} - \underset{(.082)}{.276}\, Z_{40}$$

The adjusted coefficient of multiple determination for this fit is equal to .91.

$Y_{12,s}$ = price of fresh vegetables, in tenths of dollars per ton.

Z_{41} = per capita disposable income in dollars.

Z_{49} = index of hourly marketing costs.

As is expected the farm price of fresh vegetables increases with increases in per capita disposable income and decreases with increases in the cost of moving the product to the consumers and as the supply increases.

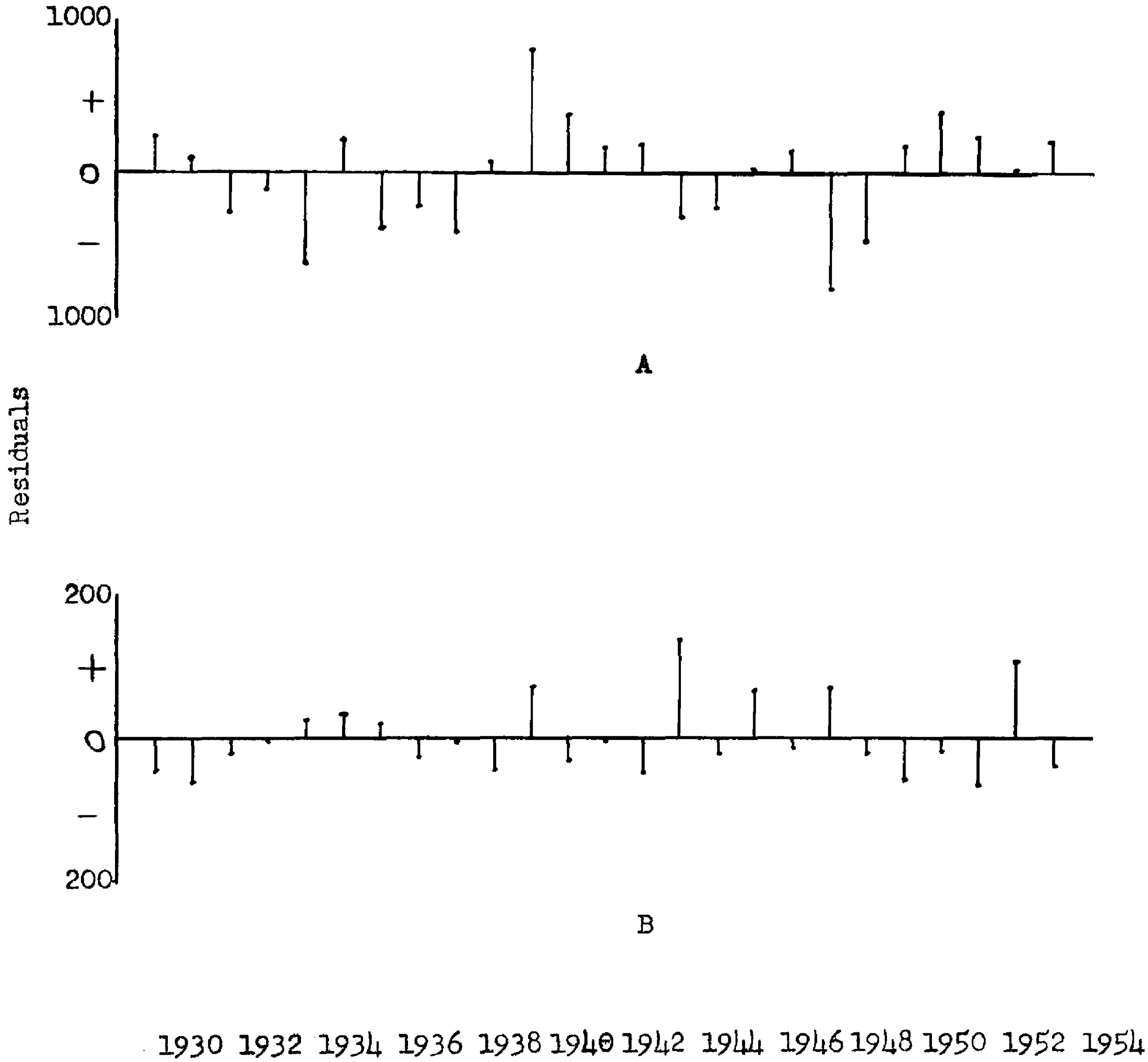

Fig. 13. Unexplained residuals for fresh vegetables.

A. Production - (thousand tons)

B. Price - (tenths of dollars per ton)

CHAPTER XI

AGGREGATIVE ECONOMIC MEASURES

The widespread use of indexes which give an indication of the economic forces operating in agriculture increases the need for the construction of aggregative measures from the model. Examples of these are the well known parity ratio, the indexes of prices received and paid by farmers, and physical production indexes.

This chapter is devoted to an application of the model in developing estimates of aggregative measures, and in comparing the model estimates with published indexes of a similar nature. The relationships which exist between some of these measures prescribe, in part, the order in which their construction occurs. This order is outlined briefly below and is followed by a more detailed explanation of the methods of construction.

The index of prices received by farmers may be derived directly from the observed or estimated prices in each product category. An index of physical production may be constructed by aggregating the observed or estimated quantities of the commodities appearing in each of the product categories. The prices paid index is only partially determined by the model and it may be constructed using the appropriate price estimates or observations from the product categories of the model in addition to prices which are exogenous to the model. The parity ratio may then be estimated since it is defined as the ratio of the index of prices received by farmers to that of prices paid. Estimates of gross farm income may be obtained by summing the products of prices and production for each of the product categories. To arrive at an estimate for net farm income, production expenses must be deducted from the gross income estimates. These expenses are determined by the quantities of inputs used and the respective prices paid for each of them. Such data are not available in this model but data of a similar nature have been generated in the form of a physical production index and the index of prices paid by farmers. Production expenses are estimated as a linear function of the indexes of physical production and prices paid by farmers. Following the estimation of production expenses, net farm income may be estimated as the difference between gross farm income and production expenses. Estimates of the above indexes, where actual prices and quantities are used in construction may be compared with published indexes of a similar nature which are constructed within the United States Department of Agriculture (USDA). Differences between estimates of the two sets of indexes will exist because the number of commodities are not equal and certain conceptual differences exist in the construction. These differences for particular indexes, are stated in the following sections which discuss each index in more detail.

Index of Prices Received

Indexes of prices received by farmers are designed to measure the level of, and year-to-year changes in prices received by farmers for commodities sold. The individual price series for each product category in the model represent average annual prices for marketings throughout the nation and therefore have limited usefulness when applied to any particular grade or variety. From these price series is constructed a fixed-weight aggregative index of prices received by farmers for the commodities included in the product categories. This fixed weight type of index is commonly called a Laspeyres[1] index and is defined symbolically as:

$$P_{rt_o} = \frac{(Y_{ia})_t (Y_{is})_o}{(Y_{ia})_o (Y_{is})_o} \qquad \begin{array}{l} i = 1,\ 2,\ldots.13 \\ t = 1929,\ 1930,\ldots.1953 \end{array}$$

where P_{rt_o} is the index of prices received for year t expressed relative to the base period o.

$(Y_{ia})_t$ is the price received for category i during time period t.

$(Y_{ia})_o$ is the average price received for category i during the base period o, and

$(Y_{is})_o$ is the average quantity of category i sold by farmers during the base period o.

The fixed weights represent the average annual cash receipts received by farmers for each of the commodities sold during the base period 1937-41. It would be desirable, from the standpoint of ease in computation and for future comparison, to use the weights currently assigned by the United States Department of Agriculture to the 52 commodities included

[1] Originated by the German statistician Etienne Laspeyres, (1834-1913).

in their published index[a] of prices received; however, this is not feasible since only 41 commodities enter into the 13 product categories of the model. While there is a great deal of correspondence between the two sets of items some adjustments are necessary. Therefore, new base period weights are computed. Since fewer commodities are included, each one included is given a greater relative weight. The original weights of the United States Department of Agriculture series are multiplied by 1.198, the ratio of the sum of the weights (100.0) used in the Department of Agriculture index for 52 items and the weights assigned to the 41 of the 52 commodities included in this study.

The included product categories covering 41 commodities with their respective weights are given below.

Commodity	Base Weight
Wheat	7.7
Feed Grains	6.5
Soybeans	.8
Cotton	9.9
Beef Cattle and Calves	18.6
Hogs	13.1
Dairy Products	21.2
Eggs	7.4
Poultry Meats	4.8
Flue Cured Tobacco	2.6
Burley Tobacco	1.1
Commercial Vegetables (fresh market)	5.8
Processed Vegetables	.3
Total Products Included	100.0

[a] *Agricultural Prices*, United States Department of Agriculture, Agricultural Marketing Service, Crop Reporting Board, Washington, D. C., Supplement No. 1, May, 1956.

Separate weights are constructed for flue cured and burley tobaccos since they are estimated independently in the model. The Department of Agriculture weight for tobacco represents all types of tobaccos as a single commodity. Since only two types are included in the model this weight is reduced by the proportion that the farm value for flue cured and burley type tobaccos was to the farm value of all types during the base period. This weight is further adjusted by assigning a weight to burley tobacco in proportion to the magnitude of its farm value relative to flue cured tobacco during the base period. A similar procedure is followed for fresh and processed vegetables.

With these modifications and using the index formula given on page 142 the index of prices received by farmers computed from the model is presented below. In order to compare the model index for consistency the regularly published[a] index, as computed by the United States Department of Agriculture, is also given.

The major reasons for deviations between these two indexes in any one year are as follows:

1. The pricing period differs for the price data used in constructing the index. The published (USDA) index collects price data at the point of sale for each product on a monthly basis, aggregates these to derive state averages and further aggregates to estimate a national average price for all grades and qualities combined. The model index is conceptually the same but in some cases is derived by dividing total

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[a] *Op. cit.*

TABLE I

INDEXES OF PRICES RECEIVED BY FARMERS, ANNUAL AVERAGES FOR ALL FARM PRODUCTS (1934-37=100)

Year	Model Index Based on Observed Prices	USDA Published Index
1929	133	138
1930	107	116
1931	78	80
1932	60	60
1933	67	65
1934	81	83
1935	101	101
1936	106	106
1937	109	113
1938	92	90
1939	87	88
1940	91	91
1941	121	116
1942	150	148
1943	175	178
1944	173	183
1945	184	191
1946	219	219
1947	256	256
1948	273	266
1949	234	231
1950	248	240
1951	283	281
1952	268	268
1953	244	240

cash receipts by production to get an average price for all grades and qualities. Deviations between the price series will cause corresponding deviations between the two indexes of prices received.

2. The number of commodities included are not identical. As described above the published (USDA) index includes 52 commodities while the model index includes only 41 of these. This causes a difference in the weights assigned to each commodity and is reflected in the estimates of the two respective indexes.

3. The published index uses two base-weight periods--1924-29 base-weights for the period preceding 1934, and 1937-41 base-weights for subsequent years. In contrast the model index uses only the 1937-41 base weights. It can be observed from Table I that the model index underestimates the published index for the earlier years and overestimates it for the later years.

Index of Physical Production

The second aggregative measure developed is that of total farm production. Several separate production series, each developed for a particular use, are currently published[4] by government agencies. The index developed in this model is designed to measure annual changes in the quantities of the major farm products produced and available for

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[4] The major series summarizing production changes which have been developed by the United States Department of Agriculture are (a) indexes of volume of crop and livestock production, (b) index of volume of total farm output, (c) index of volume of farm marketings and home consumption, (d) index of volume of gross farm production.

commercial sale or as a farm household good. Due to assumptions made in the model regarding the equality of production and sales for some commodities, this index is not a complete measure of either total production or total sales. For instance in the beef and hog product categories, production is assumed equal to consumption which is measured by data on total liveweight slaughterings. In comparison, in the case of wheat total production is included as the quantity component of the physical production index.

Since the production index estimated from the model combines the volume of crop and livestock production it is necessary to avoid double counting by either

(a) subtracting the amount of feed fed to livestock from the feed grain component, or

(b) subtracting the value of feed consumed by livestock from the livestock component.

The first method is used in this analysis by deducting from total feed grain production, the amount fed during the crop year. The remainder of feed grain production is assumed to be sold during the calendar year in which it is produced.

The production index estimated from the model is constructed using the Laspeyeres' formula,

$$Q_t = \frac{(Y_{1i})_t (Y_{ia})_o}{(Y_{1i})_o (Y_{ia})_o}, \; (i = 1,2\ldots13),(t = 1929,1930\ldots1953)$$

where Q_t is the index of physical production in year $\underline{t}$,

$(Y_{1i})_t$ is the production of the $i^{\underline{th}}$ category during year $\underline{t}$,

$(Y_{i1})_o$ is the production of the i^{th} category during the base period o and

$(Y_{i2})_o$ is the average price received for the i^{th} category during the base period o.

The price weights are proportional to those used in the index[5] of volume of farm marketings and home consumption. Adjustments are necessary because the number of commodities included are unequal between the published index of volume of farm marketings and home consumption, and in the product categories of the model. The value of those commodities included in the model equals approximately 85 percent of the value of those in the index from which the price weights are taken; thus each price weight is multiplied by 100/84.66 to get the price weights for the model.

Using the adjusted price weights, an index of physical production based upon observed quantities from the model is computed and presented below as the model index. For purposes of comparison, two other indexes are presented. The first is the index[6] of volume of farm marketings and home consumption and the second is the index[7] of farm output. These

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[5] This index and the price weights for the included commodities are published in Consumption of Food In the United States, 1909-52, United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., Handbook No. 62, September 1953.

[6] R. W. Grove, and M. F. Cannon, New Index Numbers of Farm Marketings and Home Consumption, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., Handbook No. 109, July, 1956.

[7] Changes in Farm Production and Efficiency, 1955 Summary, United States Department of Agriculture, Agricultural Research Service, Washington, D. C., June, 1956.

three indexes follow the same general pattern through time, since marketings may be expected to equal production in the long run. However, differences exist between the three indexes in any one year. Some of the major reasons are explained below.

1. Two base weight periods are used for the farm output and farm marketings indexes, having 1935-39 base weights until 1939 and 1947-49 base weights in subsequent years, while the model index of physical production uses only 1947-49 base weights.

2. The number of included commodities is not identical in all three indexes.

3. The farm output index measures the volume of production when it is produced and the index of marketings and home consumption measures volume when it is sold by farmers or consumed in the household. By comparison, the model index of physical production measures production for those categories where farm inventories have been accounted for or are non-existent, and sales where inventories are important but are not explicitly considered in the model. Thus, the increase or decrease of inventories can cause differences in the computed index numbers.

4. The farm output index credits all feed produced to the crop component of the index and deducts feed fed from the livestock component while the other two indexes deduct feed fed from the crop component and treat it as a net addition to the livestock sector.

For comparative purposes the index constructed from the model observations will generally approximate more closely the index of volume of farm marketings and home consumption than it will the index of farm

TABLE 2

INDEXES OF PHYSICAL PRODUCTION
(1947-49=100)

Year	Model Index	Index of Farm Marketing And Home Consumption	Index of Farm Output
1929	73	74	74
1930	73	73	72
1931	76	74	79
1932	72	73	76
1933	66	74	70
1934	64	75	60
1935	68	69	72
1936	68	73	65
1937	81	73	82
1938	76	77	79
1939	77	79	80
1940	80	82	83
1941	81	85	86
1942	90	93	96
1943	91	98	94
1944	101	103	97
1945	96	103	96
1946	98	102	98
1947	97	102	95
1948	105	98	104
1949	99	100	101
1950	97	99	100
1951	98	102	103
1952	107	104	107
1953	110	106	108

output. There are several reasons for this. First, the price weights used in the model index are proportional to those used in the farm marketings index and not to the farm output index. Second, the model index and the farm marketings index treat feed fed in a similar manner, i.e. deduct it from the feed component. Third, neither the model index nor the farm marketings index fully consider inventories as quantities to be weighted into the index. However, it is to be expected that the model index will produce estimates falling somewhere between the two published indexes. It does resemble the farm output index to some degree by considering for most product categories, quantities produced as the relevant quantities to be weighted into the index, whereas the farm marketings index considers the quantities sold or consumed on the farm as the relevant data to be incorporated into the index.

Index of Prices Paid

A third aggregative measure of changes in the economic condition of agriculture is provided by the index of prices paid by farmers for goods and services used in production and family living. Such an index can be broken down into its production and household living components. Only the first of these is considered in this analysis. The items used in farm production may be categorized conveniently into four commodity groups.

(a) farm expendables, including feed, seed, and livestock used for production purposes,

(b) nonfarm expendables, including motor supplies, farm equipment and supplies, and fertilizer,

(c) nonfarm durables, including motor vehicles, farm machinery, and building and fencing materials, and

(d) services, including taxes, interest on mortgages, and cash wage rates.

Since most of the commodities included in the index of prices paid by farmers for items used in production are purchased from the nonfarm sector of the economy it is not possible to estimate the index using the agricultural model alone. Partial estimation is possible by linking the items in the farm expendables commodity group to price data generated by the model. The remaining three categories are considered to be exogenous to the model.

The index is, as in the previous cases, a weighted aggregate. Weights represent average expenditures by farmers for purchased commodities with the weighting factors being proportional to the weights currently used in the published index[a] of prices paid by farmers. The weights represent average expenditures made by farmers for the included commodities during the five year period 1937-41. Inasmuch as the commodity group covering living items is excluded from the index, adjustments in the weights are necessary. Accordingly, each group representing items and services used for farm production is weighted in the proportion that expenditures on these items bore to total expenditures of all included items during the base weight period. The adjusted weights used for each category are given below.

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[a] Agricultural Prices, United States Department of Agriculture, Agricultural Marketing Service. Crop Reporting Board, Washington, D. C., Supplement No. 1, October, 1956.

Commodity Group	Base Weight
A. Farm Expendables	30.7
1. Feed	18.2
2. Livestock	9.5
3. Seed	3.0
B. Nonfarm Expendables	20.7
1. Motor Supplies	9.3
2. Farm Equipment and Supplies	5.9
3. Fertilizer and Lime	5.5
C. Nonfarm Durables	22.1
1. Motor Vehicles	9.3
2. Farm Machinery	8.0
3. Building and Fencing Materials	4.8
D. Services	26.5
1. Taxes on Real Estate	6.8
2. Interest on Mortgage Indebtedness	5.4
3. Cash Farm Wage Rates	14.3

Ideally, the construction of a prices paid index would involve quantity weights as given above and commodity price data which are generated by a set of structural relations describing the agricultural and non-agricultural sectors of the economy as a unit. Since such a model is not available, the price data used in constructing the prices paid index are considered to be endogenous for the commodity group involving farm expendables, and exogenous for the remaining three commodity groups.

Price data on feed are assumed to be identical with feed grain prices, Y_{88}, which are estimated in an earlier part of this model. An index of prices paid for seed is constructed by weighting the prices for wheat, corn, oats, barley and soybeans which were developed in

TABLE 3

INDEX OF PRICES PAID BY FARMERS
(1910-14=100)

Year	Model Index	U.S.D.A. Index
1929	161	166
1930	152	156
1931	134	134
1932	112	116
1933	103	110
1934	112	119
1935	123	123
1936	116	124
1937	135	133
1938	127	126
1939	119	124
1940	122	126
1941	131	134
1942	151	153
1943	166	174
1944	186	187
1945	193	196
1946	207	212
1947	241	242
1948	279	266
1949	257	257
1950	262	264
1951	292	292
1952	301	299
1953	290	286

earlier chapters. The index of prices paid for livestock is assumed to be identical with the prices received by farmers for cattle and calves.

For the remainder of the commodity groups, including nonfarm expendables, nonfarm durables, and services, published price data[9] are used in constructing the index.

The computed index using the adjusted weights, observable data from the model and published data is given above as the <u>model index</u>. It is computed on a 1910-14 base and compared with the United States Department of Agriculture published[10] index of prices paid by farmers for commodities used in production including interest, taxes, and wage rates.

The correspondence between the two indexes is quite good. Differences in any one year are caused by factors discussed above and include:

(a) the inclusion of fewer commodities in the feed, livestock and seed commodity group of the model index as compared to the U.S.D.A. index.

(b) different price series for the included commodities in the feed, livestock and seed commodity group of the model index as compared to the U.S.D.A. index.

However, neither of these two influences results in large discrepancies between the two indexes.

<u>Farm Production Expenses</u>

Because data are not available which break down farm production expenditures according to the product categories developed in this study,

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[9] <u>Ibid</u>.

[10] <u>Ibid</u>.

it is necessary to consider production expenses as a total for agriculture. This, unfortunately, results in an inability to obtain estimates of net income for each of the product categories.[11]

Production expenses are, of course, the quantities of inputs or services used multiplied by prices paid for these items. In a previous section of this chapter, a procedure is outlined for estimating the index of prices paid by farmers for inputs used in production including allowances for wages, taxes and interest. If the corresponding quantities of inputs used were known, production expenses could be derived as a function of such series. Such a function would equal the product of the two series only if all inputs were included and the price index was weighted correctly to account for the included inputs. This could be represented mathematically as

(11.1) $E_t = (P_{pt} \cdot I_t)$

E_t = the dollar value of production expenses for year t, in million dollars.

P_{pt} = the prices paid index for all input items in year t, 1910-14=100.

I_t = a physical index of the quantity of inputs used in production for year t.

In the absence of data on I_t and its corresponding price index P_{pt}, an estimating equation is constructed substituting the index of physical production, Q_t, for I_t. The logic of this procedure is the implicit

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[11] The Bureau of Labor Statistics compiled such estimates for the year 1947 for use in the interindustry studies of the national economy. The information on the distribution of expenses was fragmentary and scattered with no adequate time series being available to measure such a distribution over any period of years.

assumption that the index of physical production is a direct function of the index of physical inputs, or in mathematical notation,

$$(11.2) \qquad Q_t = bI_t$$

$$\text{or} \quad I_t = b^{-1}Q_t$$

If this relationship was substituted directly into (11.1) and fitted linearly by least squares it would force the regression line through the origin. There are no a priori reasons for this restriction and it is relaxed to include a constant term in the fitting process.

$$(11.3) \qquad E_t = a + b^{-1}(Q_t \cdot P_{pt}) + u$$

Data on the index of prices paid and the index of physical production have been developed in earlier portions of this chapter and represent the two series used in estimating aggregate production expenses. Observations on production expenses are taken from reports compiled by the Farm Income Branch of the United States Department of Agriculture.[12] Such estimates are generally based on enumerations in the quinquennial Census of Agriculture or on the results of special sample surveys with extrapolations and interpolations being made based on changes in available series of data of a similar nature. Where possible, changes in both quantities and "prices paid" are used in estimating expenses. Some 40 items are separately estimated and included. Current farm operating expenses include[13]: (1) wages for hired labor; (2) purchases

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[12] Estimates are published in the bimonthly issues of the Farm Income Situation, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C.

[13] Description of these data are taken from preliminary chapters of the forthcoming Statistical Handbook, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C. in process.

of feed, seed, livestock, fertilizer and lime; (3) outlays for the repair and operation of farm buildings, motor vehicles and other machinery; and (4) a list of miscellaneous expenses. Expenses in the nature of overhead costs include: (5) charges for depreciation and other capital consumption on farm buildings, motor vehicles, machinery, and equipment; (6) taxes on farm property; (7) interest paid on farm mortgage loans; and (8) net rents to nonfarm landlords. It can be seen that the items covered in the estimates of production expenses are similar to those covered in the index of prices paid by farmers.

The least squares estimates of equation (11.3) are given below in (11.4).

$$(11.4) \qquad E_t = -788.7 + \underset{(2.1695)}{7.2867}\,(Q_t \cdot P_{pt})$$

E_t = dollar value of production expenses for year t.

$Q_t \cdot P_{pt}$ = product of prices paid index and index of physical production for year t.

Judging from the size of the standard error relative to the parameter estimate the reliability of the fitted equation is good. The coefficient of multiple determination equals .98.

The computed values of production expenses along with the observed values are published in Table 4. Because an estimating equation is used which is, itself, subject to shock and observational error, the estimated values deviate from the observed values. In addition, deviations occur because the observed series includes expenses on commodities not appearing in the physical production index i.e., variations in the expenses of the omitted commodities cause differences to appear between the two series.

TABLE 4

FARM PRODUCTION EXPENSES

Year	Estimated Values Million Dollars	Observed Values Million Dollars
1929	7,313	7,631
1930	7,751	6,909
1931	6,600	5,499
1932	5,091	4,443
1933	4,137	4,296
1934	4,472	4,621
1935	5,288	4,986
1936	4,924	5,538
1937	7,182	6,044
1938	6,250	5,759
1939	5,856	6,060
1940	6,279	6,652
1941	6,979	7,603
1942	9,099	9,855
1943	10,272	11,405
1944	12,971	12,106
1945	12,648	12,839
1946	14,032	14,240
1947	16,320	16,794
1948	20,568	18,613
1949	17,829	17,885
1950	17,814	19,214
1951	20,124	22,224
1952	22,778	22,441
1953	22,434	21,219

FARM INCOME

Gross Farm Income

Given the prices received by farmers, and the production of each of the twelve product categories, it is possible to construct gross farm income estimates. In mathematical notation, this may be represented as

$$(11.5) \quad R = \sum_{i=1}^{12} (Y_{i2} \cdot Y_{i1})$$

R = gross farm income from production.

Y_{i1} = production of i^{th} commodity.

Y_{i2} = price of i^{th} commodity.

Conceptually, a more accurate estimate of gross income could be made by considering separate demand outlets. This would correspond more closely to gross income from cash receipts.

$$(11.6) \quad R' = \sum_{i=1}^{12} [Y_{i2} \cdot (Y_{i3} + Y_{i5}) + Y_{i2}' \cdot (Y_{i4}) + Y_{i2}'' \cdot (Y_{i6})]$$

where R' = gross cash receipts.

Y_{i2} = price of i^{th} commodity going into commercial or inventory demands.

Y_{i3} = commercial demand.

Y_{i5} = inventory demand.

Y_{i2}' = export price.

Y_{i4} = export demand.

Y_{i2}'' = average support price.

Y_{i6} = government demand.

However, to satisfy equation (11.6) and derive estimates of cash marketings the actual quantities and prices involved in each type of demand must be known. In addition data on redemptions of price support loans would be necessary. As an alternative, the model estimates of gross farm income are derived by valuing current production of the first eleven categories at market prices and summing these for all categories as shown in (11.7). For the final category which includes all commodities not in the first eleven categories, income is assumed to be known and is added as a constant r_{12}.

$$(11.7) \quad R = \sum_{i=1}^{11} (Y_{i2} \cdot Y_{i1}) + r_{12}$$

This series approximates the published estimates[14] of cash receipts from farm marketings which are used as a basis for USDA estimates of farm income. Differences in any one year exist because the two series are not conceptually identical. The published index measures cash receipts as the product of sales and price while the model index measures production times price for the crop categories and sales times price for categories covering livestock products. Thus changes in inventories will cause deviations between the two series. In addition the model values all production at season average prices which include an allowance for unredeemed loan and purchase agreements but with no provisions being made for redemptions. In the USDA published index separate income estimates are made of commercial sales and sales to government. The method used is to apply mid-month prices to monthly sales, add the monthly value

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[14] *Farm Income Situation*, *op. cit.*

TABLE 5

GROSS FARM INCOME FROM FARM MARKETINGS, 1929-53

Year	Model Estimates Based on Observed Values (million dollars)	Published Estimates (million dollars)
1929	11,973	11,312
1930	9,578	9,055
1931	6,973	6,381
1932	5,282	4,748
1933	5,860	5,332
1934	6,539	6,357
1935	8,236	7,120
1936	9,168	8,391
1937	9,944	8,864
1938	8,339	7,723
1939	8,363	7,872
1940	8,829	8,382
1941	12,152	11,111
1942	16,595	15,565
1943	20,118	19,620
1944	21,271	20,536
1945	21,599	21,663
1946	25,982	24,770
1947	28,442	29,664
1948	31,231	30,253
1949	26,834	27,864
1950	27,822	28,405
1951	32,055	32,909
1952	32,309	32,538
1953	30,598	31,169

of loans, and subtract the monthly value of redemptions. Thus one would expect the model estimates to differ from the published estimates. For purposes of comparing such conceptual differences the two series are given in Table 5. The model estimates are based on actual observations of prices and quantities.

Net Cash Farm Income

The difference between the model estimates of gross farm income and production expenses represents net farm income. This net cash income estimate can be made comparable with the concept of "net income of farm proprietors," as published in national income reports of the Department of Commerce by adding several additional income sources. These would include government payments made direct to farmers (e.g. conservation, Sugar Act), value of farm products consumed in the household, gross rental value of farm dwellings, and the net change in farm inventories.

Estimates of net cash farm income have been made for the sample period. The estimating procedure is to subtract from the model estimates of gross income from farm marketings, as they appear in Table 5, the estimates of production expenses derived by applying the estimating equation for production expenses to observable data of the sample period. These production estimates appear in Table 4. To compare these net cash income estimates of the model with those most closely represented by current published estimates Table 6 is presented below. Since gross income and production expenses are estimated using observed values the net farm income estimates are also based upon observed values for the

TABLE 6

ESTIMATES OF NET FARM INCOME

Year	Model Estimates Based On Observed Values (million dollars)	Estimates Based On U.S.D.A. Data (million dollars)
1929	4,480	3,681
1930	1,827	2,146
1931	367	882
1932	191	305
1933	1,723	1,036
1934	2,067	1,736
1935	2,948	2,134
1936	4,244	2,853
1937	2,812	2,820
1938	2,089	1,964
1939	2,507	1,812
1940	2,550	1,730
1941	5,173	3,508
1942	7,496	5,710
1943	9,846	8,215
1944	8,300	8,430
1945	8,951	8,824
1946	11,950	10,530
1947	12,122	12,870
1948	10,663	11,640
1949	9,005	9,979
1950	10,008	9,191
1951	11,931	10,685
1952	9,533	10,097
1953	8,164	9,950

sample period. However, they will differ from published estimates because, (1) the regression equation used in computing production expenses is subject to error and (2) the method of constructing gross farm income estimates from the model differs from that used by official agencies.

CHAPTER XII

EMPIRICAL AND STATISTICAL BASES FOR EVALUATING THE MODEL

Empirical estimates are not easily evaluated since they may be used for many different purposes. If one is interested only in estimating demand or supply elasticities, the usefulness of an empirical model may be judged by observing and testing the parameters in each structural relation. On the other hand, for success in forecasting future events exact structural relations are neither a necessary nor a sufficient condition since an estimation of possible structural changes may also be required. Usually a combination of formal statistical and subjective tests are required to evaluate an empirical model.

This chapter is divided into six parts devoted to testing the model through formal statistical tests or by comparing the results of the model with a priori knowledge. The first of these covers the validity of the model as a mechanical predicting device where all variables are observed. The second deals with forecasting varibles in nonobservable situations in terms of both mechanical and personal judgment techniques. The third and fourth sections consider the statistical significance of the estimated parameters and the realism of assuming serial independence of the disturbances. The fifth area is a test of the model by deriving elasticities and comparing them with independent a priori knowledge. The final section concludes the chapter with a short discussion of some possible shortcomings in this model.

In estimating the coefficients of the model the behavior of people, goods and services was observed and measured for the years 1929-53. One way of evaluating the theory and methods of estimation is to test its predictions and/or forecasts against data not used in constructing the estimates. Two methods of testing are distinguished in this analysis. The first is termed <u>prediction</u> and is designed to test what might be called the goodness-of-fit of the model. In contrast to prediction the usefulness of the model as a basis for future policy or management decisions lies in its ability to <u>forecast</u>. Forecasting involves the estimation of endogenous variables outside of the sample period where values of the predetermined variables may, or may not, be observable.

<u>Prediction of Endogenous Variables</u>

Prediction involves calculating the residuals for each structural relation using the estimated parameters along with observed values of variables which <u>fall outside the sample period</u>; i.e., it is an extrapolation of each structural relation where there exists a set of observations against which the extrapolations may be checked. If the model is valid the residuals of each equation should fall within prescribed tolerance limits. However, it is difficult to isolate the causes of deviations between the predicted and observable values since any or all of the following explanations may hold.

1. Structural changes may have occurred outside the sample period.
2. The estimated parameters may differ importantly from the true parameters.
3. The disturbances do not have means equal to zero.

The model is tested for the years 1954, 1955 by predicting the values of all endogenous variables. These predictions are made using the estimated parameters of each structural equation and observed values of the appropriate variables. The method of estimation, i.e., limited information or least squares, is also indicated in the following table.

Using the predicted values in Table 1 and the methods of constructing aggregates outlined in Chapter XI aggregative measures are predicted for 1954 and 1955 and presented in Table 8. The observed aggregate values are constructed by aggregating the observed variables in each product category according to the procedure given in Chapter XI, and corresponds to the "model estimates" published in Tables 1-6.

Deviations between predicted and observed values are caused by one or more of the reasons outlined above.

For the prices received index, the prices of almost all product categories are overestimated. However, the major part of the deviation is caused by the beef cattle and cotton categories. Had correct estimates been made for these two categories the deviation for 1954 would be reduced to seven index points, and correct estimates for cotton alone in 1955 would reduce the deviation to 12 points. The direction of change was correct between the two years and the percentage reductions in the predicted and observed indexes were almost identical.

TABLE 7

PREDICTIONS OF ENDOGENOUS VALUES FOR 1954, 1955

Variable		1954 Predicted	1954 Observed	1955 Predicted	1955 Observed	Method of Estimation
Wheat						
Production (bu X10⁶)	Y_{11}	1,299	984	1,313	937	LS
Price (cts/bu)	Y_{12}	236	212	230	198	LISE
Commercial demand (bu X10⁶)	Y_{15}	641	578	611	581	LISE
Inventory demand (bu X10⁶)	Y_{16}	147	50	121	79	LISE
Government demand (bu X10⁶)	Y_{17}	372	391	297	265	LISE
Feed Grains						
Production (tons X10⁶)	Y_{21}	1,243	1,232	1,228	1,303	LS
Price (1910-14=1000)	Y_{22}	2,793	2,100	2,413	2,063	LISE
Commercial demand (tonsX10⁴)	Y_{23}	10,814	10,190	10,474	10,159	LS
Government demand (tonsX10⁴)	Y_{24}	1,306	1,440	1,258	1,661	LISE
Inventory demand (tonsX10⁴)	Y_{25}	1,323	930	1,367	960	LISE
Beef						
Production (lbs x 10⁶)	Y_{31}	24,348	26,845	25,415	26,890	LISE
Price (cts/lb X10⁻²)	Y_{32}	2,173	1,619	1,516	1,587	LISE
Dairy Products						
Production (lbs x 10⁸)	Y_{41}	1,167	1,221	1,176	1,235	LISE
Price (cts/cwt)	Y_{42}	462	386	473	388	LISE
Hogs						
Production (lbs x 10⁷)	Y_{51}	1,910	1,719	1,853	1,760	LISE
Price (cts/lb X 10⁻²)	Y_{52}	1,754	2,160	1,894	1,500	LISE
Poultry Meat						
Production (lbs X10⁷)	Y_{61}	549	589	611	595	LISE
Price (cts/lb)	Y_{62}	48	37	45	39	LISE
Eggs						
Production (mill X10²)	Y_{71}	504	635	466	603	LISE
Price (cts/doz)	Y_{72}	34	23	29	25	LISE
Soybeans						
Production (bu X10⁵)	Y_{81}	3,274	3,411	3,565	3,711	LS
Price (cts/bu)	Y_{82}	256	246	247	220	LISE
Price oil (cts/bu)	Y_{83}	124	130	124	139	LISE
Price meal (cts/bu)	Y_{84}	196	142	188	124	LISE
Amount crushed (bu X10⁵)	Y_{85}	2,456	2,490	2,674	2,831	LISE
Cotton						
Production (bales X10³)	Y_{91}	13,723	13,696	13,736	14,721	LS
Price (cts/lb X10⁻¹)	Y_{92}	407	336	480	324	LISE
Mill consumption(balesX10³)	Y_{95}	9,731	8,841	11,152	9,202	LISE
Inventory demand(balesX10³)	Y_{96}	4,797	3,013	5,584	4,644	LISE
Government demand(balesX10³)	Y_{97}	6,852	2,236	8,589	6,114	LISE
Flue Tobacco						
Production (lbs X10⁶)	$Y_{10,1}$	1,374	1,314	1,349	1,483	LS
Price (cts/lb X10⁻¹)	$Y_{10,2}$	589	527	589	527	LISE
Government demand(lbsX10⁶)	$Y_{10,4}$	1,245	130	382	291	LISE
Commercial demand(lbsX10⁶)	$Y_{10,6}$	1,244	1,184	1,058	1,192	LISE
Burley Tobacco						
Production (lbs X10⁶)	$Y_{11,1}$	567	668	470	507	LS
Price (cts/lb X10⁻¹)	$Y_{11,2}$	535	498	586	654	LISE
Commercial demand(lbsX10⁶)	$Y_{11,3}$	515	447	397	486	LISE
Government demand(lbsX10⁶)	$Y_{11,4}$	42	221	73	68	LISE
Fresh Vegetables						
Production (tons X10³)	$Y_{12,1}$	9,513	10,287	9,503	10,289	LS
Price (dol/ton X10⁻¹)	$Y_{12,2}$	863	709	833	764	LS
Processed Vegetables						
Production (tons X10³)	$Y_{13,1}$	6,055	5,906	5,856	6,143	LS
Price (dol/ton X10⁻¹)	$Y_{13,2}$	474	409	462	411	LS
Feed Grains						
Net fed (tons X10⁴)	Y_{27}	239	228	168	243	

TABLE 8

PREDICTED,[1] OBSERVED,[2] AND OFFICIAL[3] ESTIMATES OF AGGREGATES 1954, 1955

Aggregate	1954 Predicted	1954 Observed	1954 Official	1954 Deviation[4]	1955 Predicted	1955 Observed	1955 Official	1955 Deviation
Prices rec. (1934-37=100)	260	234	231	+16	249	222	219	+27
Production (1947-49=100)	107	110	108	-3	107	111	112	-4
Prices paid (1910-14=100)	308	287	286	+21	296	290	286	+6
Prod. Expenses (million dollars)	23,225	21,410	21,410	+1,815	22,289	21,570	21,570	-719
Gross Income (million dollars)	35,980	31,397	31,840	+4,583	34,959	30,623	31,032	+4,336
Net Income (million dollars)	12,755	9,987	10,430	+2,768	12,670	9,053	9,462	+3,617

[1] "Predicted" represents the use of model estimates of values in constructing the aggregates.

[2] "Observed" represents the use of observed values in constructing the aggregates.

[3] "Official" aggregates represent measures of a similar nature published by the United States Department of Agriculture in the Farm Income Situation, op. cit.

[4] "Deviation" is the difference between predicted and observed estimates.

For the aggregates on physical production the deviations are much smaller. Production is underestimated which, in part, accounts for the overestimation of prices received by farmers. Again it is the beef category that is underestimated by the largest amount. A correct prediction for 1954 would have eliminated all the deviation and a correct prediction for 1955 would decrease it by half.

In the prices paid index, the predicted values involve observed input prices for all commodities except feed, seed, and livestock. The overestimation of livestock prices accounts for part of the positive deviation with feed grain prices also being responsible. It is likely that the same set of circumstances is responsible for the deviations in all of the above predicted aggregates; i.e. an overestimation of feed grain prices, the consequent underestimation of beef production and the accompanying overestimation of beef prices.

The predictions for production expenses are based on the linear regression (11.3), while the observed values are the officially published government estimates.

The overestimation of gross farm income is a result of the overestimation of prices received by farmers. The underestimation of production is not great enough to balance the error in prices when computing income. The same is true of net farm income which is calculated as the difference between gross income and production expenses.

The model predictions for 1954-55 are judged to be fairly reliable. In most cases the direction of movement is correct. The government demand equations for wheat, feed grains and burley are reasonable, but for cotton and flue cured tobacco the errors are very large for 1954. For livestock, and livestock product prices, the predictions are fairly accurate in indicating change but tend to overestimate levels for the two years considered. This process of mechanical prediction is only a basis for judging what future values will be, and it is believed that fairly accurate point forecasts can be made if external knowledge is also relied upon during the estimating process. The use of additional information could be used to account for a part of the deviations which occur in the above examples.

Forecasting Endogenous Variables

As indicated in the above section, forecasting involves the estimation of endogenous variables where values of the predetermined variables may, or may not, be observable. One unique feature of this model is that it draws upon the Klein-Goldberger national econometric model for data on predetermined, but nonobservable, variables when a forecast is to be made. Personal disposable income, wage rates and price level estimates can be predicted by the national model and used subsequently in solving this model.

The forecasting procedure can be considered in two parts. The first is mechanical, and consists of expressing each endogenous variable as a function of all of the predetermined variables, assigning values to the predetermined variables and solving for the endogenous one. The second involves the ability of the forecaster to apply flexible techniques which improve the mechanical estimate. These techniques may consist of the use of independent external information for forecasting particular parts of the system and the suppression of the corresponding structural equations, the detection of, and correction for, bias by investigating the residuals for the past few years, and the detection of temporary structural changes in the forecast period. In these cases, no purely statistical methods of adjustment are possible as the researcher's personal judgment must also be used.

The estimating procedure involved in forecasting expresses each endogenous variable as a function of predetermined variables by going to a fully reduced form. A general method of forecasting is developed below followed by an example for a particular subsystem within the model.

A general linear model, where all lagged endogenous variables and exogenous variables are represented symbolically by Z's, may be expressed in matrix notation as

$$BY' + CZ' = u' \tag{12.1}$$

Written out in more detail the system is observed to have n equations in n unknowns.

$$\begin{array}{l}
b_{11}\ y_1 + b_{12}\ y_2 + \ldots. + b_{1n}y_n + c_{1,n+1}\ Z_1 + \ldots. c_{1m}\ Z_m = u_1 \\
b_{21}\ y_1 + b_{22}\ y_2 + \ldots. + b_{2n}y_n + c_{2,n+1}\ Z_1 + \ldots. c_{2m}\ Z_m = u_2 \\
\vdots \\
b_{n1}y_1 + b_{n2}y_2 + \ldots. + b_{nn}y_n + c_{n,n+1}\ Z_1 + \ldots. c_{nm}\ Z_m = u_n
\end{array} \tag{12.2}$$

Forecasting involves estimating values for the y's for a future time period. Since the Z's are either observable or one is willing to assume values for them, and the b_{ij} and c_{ij} are the estimated structural parameters, the system may be rewritten as in (12.3). This expresses the y's as a function of the predetermined variables in each equation multiplied by their appropriate parameters plus the constant term.

Letting $-(c_{i,n+1} Z_1 + \ldots + c_{im} Z_m) + u_i = A_i$

(12.2) may be rewritten as follows:

$$
(12.3)\quad
\begin{array}{l}
b_{11} y_1 + b_{12} y_2 + \ldots + b_{1n} y_n = A_1 \\
b_{21} y_1 + b_{22} y_2 + \ldots + b_{2n} y_n = A_2 \\
\vdots \qquad\qquad\qquad\qquad\qquad\qquad \vdots \\
b_{n1} y_1 + b_{n2} y_2 + \ldots + b_{nn} y_n = A_n
\end{array}
$$

The problem in solving such a system is to estimate $y_1, y_2, \ldots y_n$ when the A_i and the b_{ij} are known. In matrix notation (12.3) may be written as

$$(12.4)\qquad B\,Y' = A'$$

where B is an nxn matrix of the b_{ij}, Y' is a vector of the unknown y's and a' is a vector of constants. If the B matrix is inverted and both sides of (12.4) multiplied by the inverse a solution of the Y' vector may be reached.

$$(12.5)\qquad B^{-1}\,B\,Y' = B^{-1}\,A'$$

$$(12.6)\qquad Y' = B^{-1}\,A'$$

Expanding (12.6) gives an expression for each Y in terms of all the predetermined variables in the system.

$$Y_1 = b_{11}^{-1}\,A_1 + b_{12}^{-1}\,A_2 + \ldots b_{1n}^{-1}\,A_n$$

$$
(12.7)\quad
\begin{array}{l}
Y_2 = b_{21}^{-1}\ A_1 + b_{22}^{-1}\ A_2 + \ldots.\ b_{2n}^{-1}\ A_n \\
\vdots \qquad\qquad\qquad\qquad\qquad\qquad\qquad \vdots \\
Y_n = b_{n1}^{-1}\ A_1 + b_{n2}^{-1}\ A_2 + \ldots.\ b_{nn}^{-1}\ A_n
\end{array}
$$

(12.7) expresses the system in reduced form. If no structural change occurs between time periods for which forecasts are to be made the b_{ij}^{-1} remain the same and it is necessary to recompute only the A_i and the Y_i in solving the system.

In most economic analyses of this type, many of the b_{ij} equal zero and it may be easier to reach a solution through algebraic manipulation rather than computing B^{-1}. An example of this method is given below using the burley tobacco subsystem.

The burley model is represented by four equations; three of them are behavioral and one an identity.

$$(12.8)\quad Y_{11,1} = -12.260 + .529\ Y_{11,2-1} + 3.189 Z_{10,6} + .548\ Z_{11,2}$$

$$(12.9)\quad Y_{11,3} = 766 - 1.674\ Y_{11,2} + .360 Z_{41} - 2.011\ Z_{11,12} + 21,049\ Z_{10,6}$$

$$(12.10)\quad Y_{11,4} = -314 + .791\ Y_{11,1} - .199 Z_{41} + .610\ Z_{11,12} + .183\ Z_{11,3}$$

$$(12.11)\quad Y_{11,1} = Y_{11,3} + Y_{11,4}$$

The first equation represents the supply relation, the second and third are the commercial and government demands and the final one equates demand and supply. The four endogenous variables ($Y_{11,1}$; $Y_{11,2}$; $Y_{11,3}$; $Y_{11,4}$) may be uniquely estimated using the four relations.

$$(12.12)\quad A_1 = -12.260 + .529\ Y_{11,2-1} + 3.189\ Z_{10,6} + .548\ Z_{11,2}$$

$$(12.13)\quad A_2 = 766 + .360\ Z_{41} - 2.011\ Z_{11,12} + 21.048\ Z_{10,6}$$

(12.14) $A_3 = -.314 - .199\ Z_{42} + .610\ Z_{11,12} + .183\ Z_{11,2}$

The system (12.8) - (12.11) may be rewritten in terms of the A_i.

$$(12.8')\quad Y_{11,1} = A_1$$

$$(12.9')\quad Y_{11,3} + 1.674Y_{11,2} = A_2$$

$$(12.10')\quad -.791Y_{11,1} + Y_{11,4} = A_3$$

$$(12.11')\quad Y_{11,3} + Y_{11,4} = A_4$$

If equations (12.8' - (12.10') are subtracted from (12.11'), $Y_{11,2}$ is expressed as a function of all the predetermined variables in the system.

$$(12.15)\quad Y_{11,3} + Y_{11,4} - A_4 - Y_{11,1} + A_1 - Y_{11,3} - 1.674\ Y_{11,2} + A_2 - Y_{11,4} + .791\ Y_{11,1} + A_3 = 0$$

Gathering terms and transposing gives (12.16).

$$(12.16)\quad Y_{11,2} = \frac{A_2 + A_3 - .209\ A_1}{1.674}$$

$Y_{11,3}$ is estimated by substituting (12.16) in (12.9').

$$(12.17)\quad Y_{11,3} = -A_3 + .209\ \ A_1$$

$Y_{11,4}$ is estimated by substituting (12.8') in (12.10')

$$(12.18)\quad Y_{11,4} = A_3 + .791\ \ A_1$$

$$(12.19)\quad Y_{11,1} = A_1$$

Ex post forecasts are made for 1954 and 1955 based upon the complete system for burley tobacco. The following table supplies the necessary data and includes the forecast values.

The A_i are computed by substituting the observed values of the predetermined values in equations (12.12) - (12.14). For 1954 the values are

TABLE 9

DATA AND FORECAST VALUES FOR BURLEY TOBACCO, 1954, 1955

Variable		1954		1955	
		Observed	Forecast	Observed	Forecast
Production	$Y_{11,1}$	668	567	470	507
Price	$Y_{11,2}$	50	53	59	65
Commercial demand	$Y_{11,3}$	447	515	397	486
Government demand	$Y_{11,4}$	221	42	73	68
Lagged price	$Y_{11,2-1}$	525		498	
Acreage	$Z_{11,2}$	399		309	
Support level	$Z_{11,3}$	464		462	
Stock/disappearance	$Z_{11,12}$	231		265	
Income	Z_{41}	1,594		1,573	
Time	$Z_{10,6}$	26		27	

$A_1 =$ 567

$A_2 =$ 1,422

$A_3 =$ 406

and for 1955 the values are

$A_1 =$ 507

$A_2 =$ 1,368

$A_3 =$ −380

When the A_i are substituted in equations (12.16) - (12.19) the forecast values of the Y_i are estimated as given in Table 9.

The solution of the model to obtain point forecasts is not difficult. In the above case it involves nothing more than simple algebra, and in most subsystems a similar procedure can be followed. If one has in mind alternative policies, i.e. varying support levels, the model represents a quick and easy method of deriving the effects on other variables within the system.

Deviations between the forecast and observable variables are due to the reasons outlined on page 168 plus an additional one. In the usual cases of forecasting the predetermined variables are not always observable since the forecast may occur when lagged variables of endogenous variables are not completely known, or some of the predetermined variables represent forces at work during the period for which a forecast is to be made, i.e. weather. Such errors of observation also cause deviations between the forecast and subsequently observable values. For this reason forecasts generally have larger deviations than predictions.

<u>Test for Serial Independence of Disturbances</u>

One of the assumptions made in the estimation process is that of serial independence of the disturbances. A test called the Durbin-Watson test,[1] has been developed to measure the degree of independence for single equation systems where the independent variables are regarded as fixed. This same test may be applied to equations containing lagged endogenous values or fitted by limited information techniques although the results are not exact.

To apply the test the statistic d' is computed.

$$d' = \frac{\sum_{t=2}^{N} (d_t - d_{t-1})^2}{\sum_{t=1}^{N} d_t^2}$$

---

[1] J. Durbin and G. S. Watson, "Testing for Serial Correlation in Least-Squares Regression I," <u>Biometrica,</u> Vol. 37 and, "Testing for Serial Correlation in Least-Squares Regression II," <u>Biometrica,</u> Vol. 38.

TABLE 10

TEST FOR SERIAL INDEPENDENCE OF DISTURBANCES

Variable	d'	4-d'	k'	d_L	d_u	Test on Hypothesis of Serial Independence
Y_{71}	1.160	2.839	3	1.02	1.54	Inconclusive
Y_{81}	1.742	2.257	5	.86	1.77	Inconclusive
Y_{82}	1.813	2.186	3	1.02	1.54	Accept
Y_{84}	1.490	2.509	3	1.02	1.54	Inconclusive
Y_{11}	1.146	2.853	4	.94	1.65	Inconclusive
Y_{15}	2.092	1.907	4	.94	1.65	Accept
Y_{26}	1.544	2.455	1	1.18	1.34	Accept
Y_{27}	1.928	2.071	4	.94	1.65	Accept
Y_{91}	1.504	2.495	5	.86	1.77	Inconclusive
Y_{92}	1.483	2.516	4	.94	1.65	Inconclusive
Y_{96}	1.419	2.580	1	1.18	1.34	Accept
Y_{97}	1.817	2.182	5	.86	1.77	Accept
$Y_{13,1}$	1.176	2.823	2	1.10	1.43	Inconclusive
$Y_{13,2}$	1.913	2.086	2	1.10	1.43	Accept
$Y_{12,1}$	1.432	2.567	2	1.10	1.43	Accept
$Y_{12,2}$	2.603	1.396	2	1.10	1.43	Inconclusive
Y_{51}	2.163	1.836	2	1.10	1.43	Accept
Y_{52}	2.001	1.998	2	1.10	1.43	Accept
Y_{31}	1.043	2.956	3	1.02	1.54	Inconclusive
Y_{32}	1.099	2.900	2	1.10	1.43	Inconclusive
Y_{61}	2.323	1.676	3	1.02	1.54	Accept
Y_{62}	2.478	1.521	2	1.10	1.43	Accept
$Y_{10,1}$	1.871	2.128	3	1.02	1.54	Accept
$Y_{10,6}$	1.979	2.020	3	1.02	1.54	Accept
$Y_{10,4}$	1.057	2.942	4	.94	1.65	Inconclusive
Y_{41}	1.306	2.693	3	1.02	1.54	Inconclusive
Y_{42}	1.600	2.399	5	.86	1.77	Inconclusive
$Y_{11,1}$	2.031	1.968	3	1.02	1.54	Accept
$Y_{11,3}$	1.323	2.676	3	1.02	1.54	Inconclusive
$Y_{11,4}$	1.866	2.133	3	1.02	1.54	Accept
Y_{72}	1.178	2.821	1	1.18	1.34	Inconclusive
Y_{22}	1.823	2.176	1	1.18	1.34	Accept
Y_{24}	2.042	1.957	3	1.02	1.54	Accept
Y_{21}	2.647	1.352	5	.86	1.77	Inconclusive
Y_{23}	.784	3.215	1	1.18	1.34	Reject

where d_t is the unexplained residual of the fitted equation for time t.

The following table indicates the absence or presence of positive or negative first order serial correlation for each fitted equation at the 5-percent probability level. N represents the number of observations and k' equals the number of predetermined variables in the equation. The test is inconclusive for certain values of the computed statistic k' since only upper and lower boundaries for each value of the critical region can be calculated. In such cases the results are designated as being inconclusive. It can be seen that in only one case was evidence of serial correlation of the disturbances definitely established using the Durbin-Watson test.

Reliability of Estimated Parameters

The point estimates of the parameters in chapters five through eleven are based on finite samples of observations. Thus, a sampling error is attached to each estimate and some idea of the reliability of the estimates is needed. For equations estimated by least squares methods, the *t* distribution may be used to form a confidence interval about the estimated parameter. If $\hat{\theta}$ is the parameter estimate, $\sigma_{\hat{\theta}}$ the estimated standard error of θ, and t_α is the entry in the tables of the t distribution corresponding to the α significance level for a given number of observations, then

$$\hat{\theta} \pm t_\alpha \sigma_{\hat{\theta}}$$

represents the confidence interval.

The statistic t may be used to test whether or not a particular variable is relevant in a structural equation, i.e. to test whether the estimated parameter differs significantly from zero. In this case the value of t is equal to the ratio of the estimated parameter to the estimated standard error. For 21 degrees of freedom, and the five percent significance level, the parameter is said to differ significantly from zero when t is computed to be 1.72 or more. In evaluating the overall reliability of the parameter estimates statistical tests were run on one hundred and thirty-eight parameters. Seventy-eight of these were significant at the five percent level, which gives a rough indication of the reliability of the model. However, each individual equation should be investigated to determine its reliability.

While the t test has been developed for least squares estimates, it also forms a rough measure of the reliability of parameters computed by the limited information technique. By observing whether the ratio of the parameter to its standard error is greater than 1.72, a rough indication of the reliability of the parameter estimates of the model is possible. An alternative to the t test is to retain parameters whenever the parameter sign supports the logic used in constructing the equation, even though a statistical test may not reject the hypothesis that the parameter equals zero. This procedure is followed because the t test is not designed for limited information techniques, and more importantly, while a parameter estimate may not appear to be significant, the cause may be errors of observation, improper functional form, or the presence of collinearity between supposedly independent variables, instead of the irrelevance of the variable. If there is a priori knowledge on what the expected sign should be and parameter estimates having the wrong sign and differ significantly from zero, e.g. Z_{60} in equation (8.5), they have been omitted from the fitted equation.

For equations (5.11) and (5.25), limited information estimates of the parameters were abandoned in favor of least squares estimates. For the LISE fit of (5.11) the estimated standard errors, and consequently the confidence intervals on the estimated parameters, were very large. The variance of the residuals was greatly decreased by using least squares estimates. In the case of (5.25), the LISE estimates gave residuals which were strongly auto-correlated, being negative for the first half of the sample period and positive for the latter half. Resorting to least squares estimates gave an inconclusive result when testing for auto-correlation.

Demand and Supply Elasticities

From the individual equations, it is possible to derive estimates of percentage changes which occur in one variable as another undergoes change. Several different measures are possible based upon the particular variable normalized, assumptions of equality between production and consumption and the existence of more than one demand curve. If supply or demand are normalized in an equation the estimated percentage changes are called elasticities, while if price is normalized they are called flexibilities. The percentage changes are usually measured with respect to a base point and in all the following cases base points are taken to be mean values of the variables.

(a) Price elasticity of supply is considered to be the ratio of the percentage change in production to the associated percentage change in the price which producers act upon in planning production. In the case of crops a lagged price is usually relevant, while for livestock products current or lagged prices may have an effect upon current production. In mathematical notation this may be written as

$$\eta_{sp} = \frac{\Delta Y_{i1}}{\Delta Y_{i2}} \cdot \frac{\overline{Y_{i2}}}{\overline{Y_{i1}}}$$

η_{sp} is the supply elasticity with respect to price and ΔY_{i1} and ΔY_{i2} are respectively the unit changes in the supply and price of the i^{th} commodity. The ratio of these changes is equal to the price parameter in an equation where production is normalised. $\overline{Y}_{i1}$ and $\overline{Y}_{i2}$ are respectively the mean values of production and price of the i^{th} commodity.

(b) Price elasticity of demand is the ratio of the percentage, change in the demand of a commodity to the associated percentage change in its price. This may be written as

$$\eta_{dp} = \frac{\Delta Y_{ij}}{\Delta Y_{i2}} \cdot \frac{\overline{Y_{i2}}}{\overline{Y_{ij}}}$$

η_{dp} is the demand elasticity with respect to price. ΔY_{ij} is the unit change in the j^{th} demand for the i^{th} commodity, and is written in this form to account for the existence of several demand outlets for an individual commodity e.g. commercial, inventory, export and government demands. The remaining variables are the same as described in (a). The ratio $\frac{\Delta Y_{ij}}{\Delta Y_{is}}$ is the price parameter in an equation where the quantity used in the j^{th} demand is normalized.

(c) Income elasticity of demand is the ratio of the percentage change in demand to the associated percentage change in income. This may be written as

$$\eta_{dy} = \frac{\Delta Y_{ij}}{\Delta Z_{41}} \cdot \frac{\bar{Z}_{41}}{\bar{Y}_{ij}}$$

η_{dy} is the demand elasticity with respect to income. ΔZ_{41} and $\bar{Z}_{41}$ are respectively the unit change and mean for per capita disposable income. ΔY_{ij} is explained above in (b). The ratio of ΔY_{ij} to ΔZ_{41} is the income parameter in equations where the quantity utilized in the j^{th} demand is normalized.

(d) Price flexibility of demand is the ratio of the percentage change in price to the associated percentage change in the quantity demanded. This may be written as

$$f_{pd} = \frac{\Delta Y_{is}}{\Delta Y_{ij}} \cdot \frac{\bar{Y}_{ij}}{\bar{Y}_{is}}$$

f_{pd} is the price flexibility with respect to demand and all other variables have been described above. The ratio ΔY_{is} to ΔY_{ij} is the parameter of the quantity variable in a demand equation where price is normalized. If only one demand outlet existed for a commodity, and if demand equalled production $f_{pd} = \frac{1}{\eta_{dp}}$, as in the case of vegetables in this model. However, in the existence of alternative demand outlets this reciprocal relationship does not hold.

(e) Price flexibility of income is defined as the ratio of the percentage change in the price of a commodity to the associated percentage change in per capita disposable income. This may be written in mathematical notation as

$$f_{py} = \frac{\Delta Y_{1s}}{\Delta Z_{41}} \cdot \frac{\bar{Z}_{41}}{\bar{Y}_{1s}}$$

f_{py} is the price flexibility of a commodity with respect to income and all other variables have been defined above. The ratio of ΔY_{1s} to ΔZ_{41} is equivalent to the parameter on income where price is normalized in an equation.

The following table indicates the estimates of elasticities and flexibilities computed in this model and the type of statistical estimation involved in computing the structural parameters. Limited information estimates are written as LISE, while least squares estimates are designated as LS.

The values given in Table 11 may be compared with other studies for consistency and plausibility and as a check on the validity of the model. It is appropriate to evaluate those elasticities which appear to be inconsistent with accepted values. In the case of soybeans the price elasticity of supply appears to be too low. A very good explanation is the changing nature of soybean production. In the early sample period little change took place in production but when the demand for soybeans increased tremendously during and following World War II production expanded rapidly. Thus the average elasticity is too low and an estimate based upon the past twelve to fifteen years would be more appropriate.

TABLE 11

ESTIMATES OF ELASTICITIES AND FLEXIBILITIES BASED UPON FARM PRICES

Variable of Normalization	Method of Estimation	Price Elasticity of Supply	Price Elasticity of Demand	Income Elasticity of Demand	Price Flexibility of Demand	Price Flexibility of Income	Reciprocal of Price Flexibility of Demand
Wheat							
Production	LS	0.129					
Commercial demand	LISE		-0.518	1.426			
Inventory demand	LISE		-0.601				
Government demand	LISE		3.677				
Feed Grains							
Production	LS	0.364					
Commercial demand	LISE		-2.544				
Inventory demand	LISE		-1.776				
Government demand	LS		5.934				
Beef Cattle							
Production	LISE	0.037					
Price	LISE				-1.329	0.311	-.752
Dairy							
Production	LISE	0.212					
Price	LISE				-1.484	0.782	-.674
Hogs							
Production	LISE	0.130					
Price	LISE				-0.422	0.038	-2.370
Poultry Meat							
Production	LISE	0.678			[illegible]	[illegible]	[illegible]
Price	LISE						
Eggs							
Production	LISE	0.298			-0.965	1.409	-1.036
Price	LISE						
Soybeans							
Production	LS	0.014 .171					
Price of oil	LISE			-0.483	0.0532		18.796
Price of meal	LISE				0.263		3.802
Cotton							
Production	LS	0.361					
Commercial demand	LISE		-0.300	0.953			
Inventory demand	LISE		-0.211				
Government demand	LISE		1.252				
Flue Tobacco							
Production	LS	0.516					
Commercial demand	LISE		-5.759	2.678			
Government demand	LISE		2.674				
Burley Tobacco							
Production	LS	0.381					
Commercial demand	LISE		-1.325	0.767			
Government demand	LISE		~~8.749~~ [illegible]				
Fresh Vegetables							
Production	LS	0.316					
Price	LS				-0.586	1.684	-1.706
Processed Vegetables							
Production	LS	0.416					
Price	LS				-0.175	1.510	-5.714

The negative income elasticity for soybean oil is also unrealistic and may also be due to this rapid shift. The income elasticity for wheat is usually considered to be negative, contrary to the result in Table 11, and no simple explanation appears to be possible. It may be that the "per capita income" variable also includes the effect of population increases and as both trend upward the demand for wheat increases in accordance with population increases. Proper reservations should be attached to all estimates connected with the demand relations for flue cured tobacco, since none of the estimated parameters differed significantly from zero at the five percent level according to the t test. In general, more faith can be placed in the supply elasticities than in the demand elasticities except for soybeans.

Development of Additional Research

The use of a broad brush in painting an economic picture of agriculture results in some areas being barely covered. In the event that this model is refined and developed further, the following discussion indicates some of the particular areas requiring additional study.

As indicated in the objectives, this study is not intended to represent a complete analysis of each product category. It does attempt to achieve balance between categories and treat each in sufficient detail that useful aggregates may be constructed. As more observations become available, it will be possible to add more detail to each product category. In particular, the export market should be considered endogenous, especially for the wheat, cotton and flue cured tobacco product categories. In addition, commercial demand as defined in the model could be further refined for several products. For wheat a "livestock feed" demand equation should be developed and possibly "industrial" versus "food" demand functions are also relevant. These last two demands should also appear in the feed grains category. For milk, it would be worth-while to consider product demand functions, i.e. fluid, manufactured, butter, cheese or cream. The demand function for cotton is inadequate and information on manufacturers' stocks/unfilled orders ratio would be helpful in refining it.

The method of including government demand is an improvement over most analyses but still lacks precision. The assumption that products move under loan programs when free market prices fall below support prices does not always hold since legal restrictions are often imposed on the eligibility of products for price supports. Additional data on government operations would also make possible the treatment of government release of stocks as an additional source of supply.

The inclusion of the war years may be a cause of error since it may tend to overestimate income elasticities and underestimate price elasticities for commodities which were influenced by price ceilings. The marketing structure for farm products is much in need of additional study. An attempt was made to include it but was abandoned for the lack of adequate data. In addition to data requirements the theory covering marketing is inadequate in view of the rapidly changing technology. Such technology also extends to other parts of the model and could be developed in much more detail as data and techniques of aggregation are developed.

The model should not be considered as a static set of structural relations. As new data become available they should be incorporated into the model and the parameters recomputed. The occurrence of structural changes of a permanent or semi-permanent nature should also be incorporated either through the addition of new variables and subsequent recomputation or by subjectively evaluating the effects for particular time periods.

The supply curves applied throughout this model are assumed to be completely reversible, i.e. where single supply prices are relevant price changes cause an expansion or contraction along a single supply curve. This assumption is open to serious question and a reformulation of the supply curves may be necessary. The theoretical basis for reformulation centers around the existence of two relevant supply prices—acquisition cost and salvage value. When the marginal value product (M.V.P.) of an input is greater than its acquisition cost expansion takes place along one supply curve, and when the M.V.P. falls below the salvage price of the input supply will contract along a different curve. This may rule invalid the computed elasticities of supply and the problem should be investigated in more detail.

CHAPTER XIII

EVALUATION

Scientific method implies that it is possible to evaluate results in terms of stated objectives.

The primary objective of this study was to establish measurement of relationships in the agriculture economy which aid in management and policy decisions. This objective is met in terms of the structural relations which have been constructed and estimated. These estimates represent important relationships between sectors of the economy and within the agricultural sector. The model also includes the effects of some external factors, i.e. income, population, and the price level on demand. The forces which determine farm prices for individual product categories have been investigated on both the demand and supply sides. In most cases these investigations include effects of the marketing functions performed in transporting these goods to the consumer. As an aid in describing the consequences of technological development as it affects farm production, physical quantities of specific inputs were included in the supply relations.

The secondary objective was to develop an estimate of farm income which could be channelled back into the Klein-Goldberger national econometric model. Both gross and net income estimates have been constructed for this purpose.

The strength of the model lies in its comprehensiveness. It represents a system of thirty-five functional equations plus several identities. Approximately one hundred and ten variables were used in fitting the thirty-five equations. This study is a major effort in describing agriculture as a sector in the economy. The econometric techniques used permit a great deal of flexibility in breaking agriculture down into independent subsystems without losing the effects of major interactions. Because of this, the model may be considered by parts, i.e. there are independent but comparable analyses of eleven product categories, covering approximately eighty-five percent of the value of farm production. Comparability between the categories permits aggregation of results for application to the agricultural sector of the economy. Thus, the model is useful at two important levels--the product or category level where producer decisions are made and the national aggregate level where policy and interindustry effects are felt and appraised.

The usefulness of the model may only be determined by its repeated application as a forecasting device. The predictions and forecasts presented in Chapter XII are partial tests of the validity of the model. In most cases, the direction of change was correct although for particular commodities the forecast level of activity differed widely from that observed. In such cases, more detailed analysis is warranted. The usefulness and validity of the model are not established purely on the basis of its ability to make correct point forecasts. The model, or any part of it, when used for forecasting should be regarded as a mechanical device used to derive first approximations. These approximations may be very close to the subsequently observable values and one may choose to use them. However, caution is suggested. As seen from the reliability of the parameters relative to their standard errors, sampling variation alone is sufficient to cause large deviations between forecast and observed values. In addition the statistical analyses are based upon assumptions which in some cases are unrealistic. The use of small samples, functional forms which are linear in the observed variables, and assumptions of non-autocorrelated disturbances are all subject to question. Therefore, there is good justification in regarding with reservation the forecast values. In most cases, the approximations may be improved through the use of judgments based on information external to the model but which sheds additional light upon the sector being studied. Such judgments support, complement, and extend the model when structural changes occur between the sample period and the time period for which forecasts are being made.

The model is potentially useful as a method of deciding between the effects of alternative policies. Several forecasts may be made for a given time period in order to appraise the effects of alternative policies which would alter variables in the model. Such estimates are easy to make once the model has been expressed in reduced form by simply computing new constants based upon new values for the particular variables being varied. The flexibility of the system also permits endogenous variables to be treated as predetermined for certain time periods and their effects traced throughout the system.

One of the advantages of the system is its susceptibility to the construction of multipliers. It is possible in this way to trace secondary effects throughout particular subsystems. In addition, because the model is linked to the Klein-Goldberger national economic model, the effects of certain non-agricultural forces may be traced throughout the agricultural sector.

No attempt has been made in this thesis to develop specific areas of applicability. The strength and weaknesses of the model have been discussed to acquaint the reader with possible uses which may be made and possible areas where additional research may be undertaken. The areas of economic outlook for producers, agricultural policy formation, inter-industry studies, and consumer information all appear to be fertile areas in which application could be made. If such is the case, it is hoped that this model will be tested against reality in the future and reformulated if necessary to become a useful research and extension tool.

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APPENDIX

BASIC TIME SERIES USED IN ANALYSIS

Year	Y_{11} Production of Wheat (Bushels X10^6)	Y_{11}^* Available Supply of Wheat (Bushels X10^6)	Y_{12} Average Price of Wheat (Cents/Bushel)	Y_{15} Commercial Demand for Wheat (Bushels X10^6)	Y_{16} Non CCC Carryover of Wheat (Bushels X10^6)	Y_{17} CCC Loans on Wheat (Bushels X10^6)
1929	824	907	104	617	291	0
1930	887	1063	67	750	313	0
1931	942	1129	39	732	375	0
1932	756	1096	38	719	378	0
1933	552	901	74	628	273	0
1934	526	799	85	654	146	0
1935	628	802	83	661	140	0
1936	630	792	103	689	103	0
1937	874	854	96	697	153	0
1938	920	963	56	712	243	16
1939	741	977	69	663	278	8
1940	815	1091	67	676	216	174
1941	942	1130	94	651	311	270
1942	969	1248	109	921	359	184
1943	844	1293	135	1174	218	0
1944	1060	1171	141	936	175	73
1945	1108	890	149	874	100	0
1946	1152	850	190	744	84	0
1947	1359	953	229	754	196	0
1948	1295	985	198	672	80	291
1949	1098	877	188	676	97	248
1950	1019	758	200	680	200	42
1951	981	734	211	662	113	91
1952	1299	1112	209	681	92	398
1953	1169	1047	204	604	127	486
1954	984	842	212	578	50	391
1955	937	652	918	581	79	265

Year	Y_{21} Production of Feed Grains (Tons X10^5)	Y_{22} Price Feed Grains (1910-14=1000)	Y_{23} Commercial Demand For Feed Grains (Tons X10^4)	Y_{24} CCC Loans On Feed Grains (Tons X10^4)	Y_{25} Carryover of Feed Grains (Tons X10^4)	Y_{31} Liveweight Slaughter of Beef (Pounds X10^6)
1929	964	1240	9961	0	777	12357
1930	869	1186	9643	0	677	12380
1931	969	938	8525	0	795	12456
1932	1111	560	9433	0	991	12088
1933	841	396	10661	0	1372	13355
1934	526	746	7928	748	1071	15049
1935	923	1228	6051	56	374	14496
1936	592	882	8531	87	993	16002
1937	1001	1497	6896	0	468	15127
1938	968	946	8372	171	1383	14853
1939	958	679	8670	644	1640	14918
1940	986	809	8678	846	1609	15202
1941	1050	868	9292	305	1824	16898
1942	1208	1086	10259	349	1656	18622
1943	1121	1311	12116	194	1561	18333
1944	1167	1738	11937	24	1135	20842
1945	1138	1688	11384	76	1396	22677
1946	1230	1785	11599	10	1128	20474
1947	941	2317	10675	73	1293	22901
1948	1354	3207	9783	3	757	19927
1949	1206	2033	10597	1753	1446	19957
1950	1220	1798	9980	1347	1850	19890
1951	1129	2222	11320	334	1630	18230
1952	1197	2414	11178	155	1183	19842
1953	1176	2281	10423	1234	1075	25687
1954	1232	2100	10190	1440	930	26845
1955	1303	2063	10159	1661	960	26890

Year	Y_{32} Price of Beef (Cents/lb. $X10^{-2}$)	Y_{41} Production of Milk (Pounds $X10^{8}$)	Y_{42} Price of Milk (Cents per Cwt)	Y_{51} Liveweight Slaughter of Hogs (Pounds $X10^{7}$)	Y_{52} Price of Hogs (Cents/lb. $X10^{-2}$)	Y_{61} Production of Eggs (Millions $X10^{8}$)
1929	976	990	239	1627	942	379
1930	795	1002	207	1533	884	391
1931	570	1030	160	1585	573	385
1932	434	1038	124	1620	334	363
1933	385	1048	126	1164	353	355
1934	390	1016	149	1508	414	344
1935	621	1012	169	1027	865	336
1936	608	1024	186	1307	937	345
1937	727	1019	192	1198	950	376
1938	661	1058	166	1346	774	374
1939	742	1068	159	1530	623	388
1940	785	1094	174	1770	539	397
1941	915	1151	204	1676	909	419
1942	1105	1185	240	1891	1304	486
1943	1228	1170	289	2341	1369	545
1944	1126	1170	302	2328	1306	585
1945	1244	1198	304	1801	1400	562
1946	1488	1177	381	1883	1750	560
1947	1903	1168	412	1832	2410	554
1948	2287	1127	466	1755	2310	549
1949	2055	1161	381	1819	1810	561
1950	2404	1166	375	1900	1800	587
1951	2963	1148	440	2056	2000	593
1952	2496	1151	467	2057	1780	610
1953	1668	1215	419	1758	2140	617
1954	1619	1221	386	1719	2160	589
1955	1587	1235	388	1760	1500	595

Year	Y_{62} Price of Eggs (Cents per Dozen)	Y_{71} Production of Poultry Meat (Pounds X10^{7})	Y_{72} Price of Poultry Meat (Cents per Pound)
1929	30	275	24
1930	24	278	19
1931	18	261	18
1932	14	279	12
1933	14	284	11
1934	17	250	16
1935	23	263	19
1936	22	297	17
1937	21	260	19
1938	20	282	17
1939	17	314	15
1940	18	307	15
1941	24	366	18
1942	30	420	23
1943	37	502	29
1944	33	441	29
1945	38	516	30
1946	38	431	33
1947	45	421	32
1948	47	399	38
1949	45	498	30
1950	36	512	28
1951	48	589	31
1952	42	597	29
1953	48	624	28
1954	37	635	23
1955	39	603	25

Year	Y_{61} Production of Soybeans (Bushels $X10^5$)	Y_{62} Price of Soybeans (Cents/Bushel)	Y_{63} Value of Soybean Oil (Cents/Bushel)	Y_{64} Value of Soybean Meal (Cents/Bushel)	Y_{65} Soybeans Crushed (Bushels $X10^5$)	Y_{51} Production of Cotton (Running Bales $X10^3$)
1929	94	188	77	75	17	14825
1930	139	137	54	55	41	13932
1931	173	50	29	51	47	17097
1932	152	53	39	66	35	13003
1933	135	92	51	81	31	13047
1934	232	96	67	83	91	9636
1935	489	71	61	70	252	10638
1936	337	125	81	98	206	12399
1937	462	84	52	66	303	18946
1938	619	66	45	62	446	11943
1939	901	80	46	69	567	11817
1940	780	89	62	73	641	12566
1941	1072	155	103	100	771	10744
1942	1875	160	106	103	1335	12817
1943	1901	181	101	126	1423	11427
1944	1921	205	104	125	1534	12230
1945	1932	208	106	150	1595	9015
1946	2034	257	205	195	1702	8640
1947	1865	333	225	218	1614	11860
1948	2272	227	128	180	1837	14877
1949	2342	216	122	179	1953	16128
1950	2993	247	173	183	2520	10014
1951	2825	273	113	229	2443	15149
1952	2981	272	131	194	2344	15139
1953	2623	272	148	217	2131	16465
1954	3411	246	130	142	2490	13696
1955	3711	220	139	124	2831	14721

Year	Y_{91} * Available Supply of Cotton (Running Bales) X10³	Y_{92} Average Price of Cotton (Cents/lb X10)'	Y_{93} Mill Consumption of Cotton (Running Bales X10³)	Y_{96} Stocks of Cotton Not Under Loan (Running Bales X10³)	Y_{97} CCC Loans on Cotton (Running Bales X10³)	$Y_{10,1}$ Production of Flue Cured Tobacco (Million Pounds)
1929	16955	168	6106	3010	0	750
1930	16942	95	5263	2870	0	865
1931	19967	57	4866	7201	0	670
1932	20204	65	6137	6952	0	374
1933	19999	102	5700	6631	1926	733
1934	16167	124	5361	2705	4632	558
1935	13343	111	6351	2099	120	811
1936	14498	124	7950	2722	0	683
1937	21668	84	5748	4482	5561	866
1938	16425	86	6858	1907	4482	787
1939	13724	91	7784	1737	30	1171
1940	14303	99	9722	4979	3180	760
1941	15723	170	11170	6094	2221	650
1942	18911	190	11100	5525	3143	812
1943	16952	199	9943	4739	3594	790
1944	16969	207	9568	4093	4710	1087
1945	13108	225	9163	6387	650	1173
1946	15027	326	10025	2243	340	1352
1947	14203	319	9354	2950	640	1317
1948	17827	304	7795	1399	5270	1090
1949	17527	286	8851	3209	3190	1115
1950	13223	401	10509	2087	8	1257
1951	17236	379	9196	2390	1115	1453
1952	17529	346	9461	3512	2338	1365
1953	19977	323	8576	2618	6381	1272
1954	23349	336	8841	3013	2236	1314
1955	25861	324	9202	4644	6114 P	1483

P = Preliminary

Year	$Y_{10,2}$ Average Price of Flue Tobacco (Cents/lb. X10)	$Y_{10,4}$ CCC Loans on Flue Tobacco (pounds $X10^6$)	$Y_{10,6}$ Commercial Demand For Flue Tobacco (pounds $X10^6$)	$Y_{11,1}$ Production of Burley Tobacco (pounds $X10^6$)	$Y_{11,2}$ Average Price of Burley Tobacco (Cents/lb. X10)	$Y_{11,3}$ Commercial Purchases of Burley Tobacco (pounds $X10^6$)
1929	180	0	750	337	218	337
1930	120	0	865	349	155	349
1931	84	0	670	425	87	425
1932	116	0	374	304	125	304
1933	153	0	733	378	105	378
1934	272	0	558	252	169	252
1935	200	0	611	222	191	222
1936	222	0	683	220	357	220
1937	230	0	866	402	201	402
1938	222	0	787	339	190	339
1939	149	174	997	395	173	395
1940	164	205	555	377	162	351
1941	281	121	529	337	292	331
1942	384	247	565	344	418	343
1943	402	259	531	392	456	391
1944	424	331	756	591	440	591
1945	436	311	862	577	394	558
1946	483	67	1285	614	397	466
1947	412	232	1085	485	485	447
1948	496	106	884	603	460	506
1949	472	104	1001	561	452	522
1950	547	78	1179	499	490	455
1951	524	142	1311	618	512	521
1952	503	243	1122	650	503	546
1953	528	151	1121	564	525	407
1954	527	130	1184	668	498	447
1955	527	291	1192	470	586	397

Year	$Y_{11,4}$ CCC Loans on Burley Tobacco (pounds X10^6)	$Y_{12,1}$ Production Fresh Vegetables (Tons X10^3)	$Y_{12,2}$ Price Fresh Vegetables (Dollars/ton X10^{-1})	$Y_{13,1}$ Production Processed Vegetables (Tons X10^3)	$Y_{13,2}$ Price Processed Vegetables (Dollars/Ton X10^{-1})
1929	0	6057	400	3033	210
1930	0	6155	361	3332	213
1931	0	5945	317	2380	177
1932	0	6004	253	2043	130
1933	0	5333	292	1983	152
1934	0	6176	285	2636	157
1935	0	5986	314	3352	166
1936	0	6203	321	3323	172
1937	0	6295	338	3836	184
1938	0	6718	279	3623	178
1939	0	7302	312	3435	163
1940	26	7391	324	4018	171
1941	6	7098	422	5048	195
1942	1	7512	521	5750	263
1943	1	7375	810	4984	359
1944	0	8676	658	5303	365
1945	19	9026	743	5268	382
1946	148	9607	638	6312	399
1947	38	8502	781	5550	283
1948	97	8959	712	5467	396
1949	39	9268	715	5446	385
1950	44	9926	634	5229	395
1951	97	9425	796	7215	429
1952	104	9496	893	6664	411
1953	102	10256	727	6581	421
1954	221	10287	709	5906	409
1955	73	10289	764	6143	411

Year	Z_{12} Fertilizer Applied in N. D. & Kansas (Tons X10^3)	Z_{13} Unharvested Acreage Wheat (Acres X10^5)	Z_{14} Net Exports of Wheat (Bushels X10^6)	Z_{15} Acreage Planted to Winter Wheat (Acres X10^5)	Z_{16} Average Support Price Wheat (Cents/Bushel)	Z_{21} (Available Supply -Exports)Feed Grain (Tons X10^6)
1929	11	38	144	441	96	964
1930	8	50	115	452	59	869
1931	4	88	126	459	31	969
1932	3	84	35	436	30	1112
1933	22	196	29	448	66	841
1934	5	208	0	474	77	526
1935	7	183	-28	500	75	923
1936	11	249	-22	578	95	592
1937	16	166	103	565	88	1001
1938	19	98	110	462	59	968
1939	16	101	49	435	63	958
1940	20	85	34	460	64	986
1941	24	68	28	389	98	1050
1942	29	32	32	385	114	1208
1943	35	46	-90	468	123	1121
1944	50	65	107	505	135	1167
1945	41	40	393	522	138	1138
1946	69	45	402	582	149	1230
1947	135	38	490	583	184	941
1948	146	59	506	612	200	1354
1949	148	80	301	524	195	1206
1950	168	97	358	558	199	1220
1951	183	165	447	567	218	1129
1952	273	74	300	570	220	1199
1953	236	111	214		221	1176
1954	256	82	269	466	224	1323
1955	294	109	335	442	208	1303

Year	Z_{22} Yield Feed Grains (Tons/Acre X10^{-4})	Z_{23} Unharvested Acres of Feed Grains (Acres X10^{5})	Z_{24} Tractors and Combines on Farms (Index)	Z_{25} Animal Units Fed Beginning Oct. 1 (X10^{5})	Z_{26} Support Price Corn (1910-14=100)	Z_{27} Fertilizer Applied N. C. States (Tons X10^{3})
1929	6747	91	17	1527	1106	929
1930	6300	122	19	1536	858	920
1931	5522	157	20	1524	480	715
1932	5958	153	21	1560	316	444
1933	6542	240	21	1593	758	474
1934	5378	471	21	1537	927	598
1935	4030	209	22	1311	758	743
1936	6028	322	24	1385	927	894
1937	4295	180	28	1376	843	933
1938	6937	181	33	1376	960	879
1939	6748	240	37	1485	960	889
1940	6879	231	39	1560	1027	1061
1941	6955	195	43	1560	1264	1218
1942	7305	191	51	1673	1399	1604
1943	8133	202	57	1924	1517	1780
1944	7336	170	61	1932	1651	2174
1945	7507	166	67	1734	1702	2572
1946	7789	137	72	1677	1938	3163
1947	8347	132	78	1603	2308	3510
1948	6860	123	86	1540	2426	4103
1949	9448	110	99	1605	2359	3963
1950	8535	135	112	1661	2477	4625
1951	8472	157	124	1723	2645	4719
1952	8351	141	134	1742	2696	5484
1953	9016	153	132	1704	2696	5961
1954	1559	88	144	1651	2730	6226
1955	1583	106	146	1700	2662	6159

Year	Z_{34} Index of May-Oct. Range Condition (Per cent of 100)	Z_{35} Jan. 1 Inventory Steers & Calves (Numbers $X10^4$)	Z_{38} Price Level in U.S.A. 1939 Constant Dollars (1939=100)	Z_{41} Per Capita Disposable Income (Dollars)	Z_{42} Ratio mfrd. to Fluid Milk ($X10^2$)	Z_{43} #DHIA Association's Operating Jan.1 (X10)
1929	84	1384	114	630	193	117
1930	83	1450	113	633	190	114
1931	77	1472	111	532	198	111
1932	85	1530	100	443	199	101
1933	76	1701	96	398	208	88
1934	63	1830	86	427	217	79
1935	61	1630	92	461	207	81
1936	76	1621	91	526	200	88
1937	76	1573	88	534	195	99
1938	84	1561	94	547	206	111
1939	75	1576	100	532	200	123
1940	83	1622	97	614	205	130
1941	92	1753	102	678	195	138
1942	88	1882	116	862	183	142
1943	83	2060	125	967	170	106
1944	83	2162	127	1051	160	95
1945	84	2120	131	1063	162	95
1946	80	2054	133	1109	138	112
1947	86	1991	147	1161	150	143
1948	61	1871	157	1229	142	67
1949	83	1930	168	1318	147	179
1950	82	1933	168	1266	142	197
1951	80	2126	193	1503	130	214
1952	78	2397	189	1448	126	211
1953	80	2605	197	1481	135	215
1954	74	2561	199	1594	127	218
1955	78*	2619	201	1573	117	229

* = estimated

Year	Z_{44} Pasture Condition As Percent of Normal (Percent of 100)	Z_{45} Jan. 1 Inv. Cows & Heifers 2 Yrs. $(X10^6)$	Z_{46} Inventory Change Plus Net Exports of Milk (Pounds $X10^7$)	Z_{48} Production of Oleomargarine (Pounds $X10^6$)	Z_{49} Average Hourly Marketing Wage (Cents/hr. $X10^{-2}$)	Z_{55} Jan. 1 Inv. Sows & Gilts $(X10^6)$
1929	79	224	28	356	696	107
1930	65	230	-65	326	727	96
1931	70	238	-130	230	731	98
1932	71	249	139	203	688	98
1933	66	259	207	245	602	100
1934	53	269	155	264	619	87
1935	80	261	-90	382	618	61
1936	59	252	45	393	626	77
1937	75	246	-123	397	661	71
1938	83	245	192	385	730	76
1939	71	246	-190	301	888	95
1940	77	249	36	320	736	94
1941	77	255	293	368	784	86
1942	88	263	-298	426	854	107
1943	81	271	28	614	929	133
1944	78	277	-24	588	987	108
1945	87	278	56	614	1015	93
1946	81	265	180	573	1172	94
1947	83	258	350	746	1314	95
1948	80	246	342	908	1408	87
1949	81	239	164	862	1534	98
1950	83	239	79	937	1700	102
1951	86	237	144	1041	1866	106
1952	80	234	142	1286	1969	96
1953	81	240	-126	1292	2027	83
1954	75	247	36	1364	2057	90
1955	77	244	102	1330	2116	95

Year	Z_{65} Number Birds in NPIP ($X10^6$)	Z_{68} Jan. 1 Inv. Hens & Pullets ($X10^6$)	Z_{73} Units of Poultry Equipment ($X10^5$)	Z_{83} Row Crop Cultivators on Farms (Units $X10^2$)	Z_{84} Average July Rainfall in Illinois (Inches $X10^{-2}$)	Z_{88} Solvent Extraction of Soybeans (Percent of 100)
1929	1	404	20	33	469	1
1930	1	420	21	58	101	2
1931	2	402	24	98	297	3
1932	8	386	27	122	332	5
1933	15	391	28	145	241	7
1934	20	385	30	169	324	9
1935	35	350	31	189	336	11
1936	65	363	36	236	122	13
1937	59	380	32	324	318	17
1938	87	353	43	425	474	16
1939	107	376	49	471	337	20
1940	120	393	52	515	153	23
1941	155	381	64	581	274	24
1942	165	428	75	725	489	16
1943	203	489	81	860	300	16
1944	186	524	88	891	183	20
1945	249	474	98	968	145	28
1946	276	473	107	1023	241	27
1947	273	431	107	1078	188	38
1948	274	418	111	1234	545	40
1949	327	399	106	1491	440	56
1950	337	424	102	1616	398	72
1951	375	410	104	1683	463	74
1952	338	420	97	1877	344	86
1953	360	404	104	1938	367	90*
1954	370	414	104*	2380	279	95*
1955	375*	422	104*	2400	341	95*

* = estimated

Year	Z_{01} Percent of Cotton Acreage Grown in Far West (Percent of 1000)	Z_{02} Cotton Yield Decline Due To Climatic Factors (Percent of 1000)	Z_{03} Prices Paid Index For Cotton Farms (1947-49=100)	Z_{04} Net Exports of Cotton (Running Bales $X10^3$)	Z_{05}^* Foreign Cotton Supply (Running Bales $X10^4$)	Z_{06} Non-CCC Inv. of Cotton on July 1 (Running Bales $X10^3$)
1929	15	421	50	6675	1966	2130
1930	14	454	50	6757	1881	3010
1931	13	265	40	8707	1782	2870
1932	10	395	36	8418	1912	7201
1933	13	267	40	7531	2197	6952
1934	17	497	45	4767	2329	6531
1935	17	347	46	5971	2337	2705
1936	23	326	47	5433	2657	2099
1937	32	218	47	5595	2700	2722
1938	26	301	45	3325	2676	4482
1939	25	329	46	6163	2411	1907
1940	28	289	46	1112	2585	1737
1941	32	344	53	1125	2487	4979
1942	33	246	63	1480	2498	6094
1943	28	296	70	1138	2601	5525
1944	28	209	75	2007	2606	4739
1945	34	313	79	3613	2829	4093
1946	34	370	86	3544	2906	6387
1947	43	297	95	1968	2754	2343
1948	56	224	106	4748	2412	2950
1949	58	328	99	5769	2357	1399
1950	56	412	101	4117	2729	3209
1951	79	337	113	5515	2955	2087
1952	89	345	113	3048	3276	2390
1953	98	278	111	3760	3314	3512
1954	78	357	107	3445	3440	2618
1955	76	300e	109	2229	3448	3013

e = estimated

Year	Z_{97} CCC Inventory of Cotton on July 1 (Run. Bales X10^3)	Z_{98} Average Support Price of Cotton (Cents/lb. X10)$^{-1}$	Z_{99} U.S. Production of Synthetic Fibers (Lbs. X10^6)	$Z_{9,11}$ Fertilizer Applied to Cotton (Lbs./acre)	$Z_{10,1}$ Acreage, Allotments or Previous Years Harvest for Flue Tobacco (Thousand Acres)	$Z_{10,2}$ Average Support Price for Flue Tobacco (Cents/lb. X10)$^{-1}$
1929	0	128	122	265	1120	93
1930	1312	55	128	259	1086	100
1931	3393	17	152	230	1144	20
1932	2379	25	136	206	980	4
1933	1129	100	216	240	618	36
1934	1117	120	211	245	921	73
1935	4433	100	262	258	679	192
1936	3237	84	290	260	874	120
1937	1665	90	341	280	864	142
1938	6964	86	287	284	990	150
1939	11049	70	380	280	909	154
1940	8732	92	476	277	1270*	150
1941	7047	142	585	285	762*	196
1942	4411	172	657	293	841*	237
1943	5044	193	702	312	895*	276
1944	5887	211	772	326	1095*	289
1945	6947	211	842	337	1118*	297
1946	786	244	908	339	1257*	321
1947	55	279	1027	340	1247*	400
1948	41	307	1199	340	1161	439
1949	3819	294	1092	344	959*	425
1950	3540	295	1405	333	969*	450
1951	79	317	1499	338	1119*	507
1952	285	320	1392	341	1131*	506
1953	2000	327	1494	345	1111	479
1954	7035	351	1430		1053*	479
1955	8127	351	1716		1042	483

* = allotments

Year	$Z_{10,4}$ Higher of Support Price or Previous Year Price, Flue Tobacco (Cents/lb. X10)$^{-1}$	$Z_{10,6}$ Time	$Z_{10,7}$ June Rainfall in Raleigh N.C. (Inches X10^{2})	$Z_{10,12}$ Manufacturer's Stock Disappearance Ratio for Flue Tobacco (X10^{2})	$Z_{11,2}$ Acreage, Allotments or Previous Year's, for Burley Tobacco (Thousands)	$Z_{11,3}$ Avg. Support Price for Burley Tobacco (Cents/lb.X10)$^{-1}$
1929	173	1	499	285	330	225
1930	180	2	424	254	418	138
1931	120	3	253	295	472	75
1932	84	4	715	340	503	7
1933	116	5	144	253	410	45
1934	153	6	505	265	502	25
1935	272	7	90	234	304	89
1936	200	8	807	269	280	111
1937	222	9	381	232	303	277
1938	230	10	816	252	448	121
1939	222	11	384	226	407	110
1940	150 s	12	181	652 2.56?	375	164
1941	196 s	13	337	268	374	200
1942	281	14	434	168	379	246
1943	384	15	875	191	471	270
1944	402	16	166	162	589	282
1945	424	17	113	177	609	290
1946	436	18	512	160	557	336
1947	483	19	467	231	469	403
1948	439 s	20	227	185	463	424
1949	496	21	561	185	468	403
1950	472	22	725	194	418	457
1951	547	23	340	210	472	498
1952	524	24	143	226	475	495
1953	503	25	419	281	426	466
1954	528	26	112	209	399	464
1955	527	27	213	232	309	462

s = support price

Year	$Z_{17,18}$ Burley Manufacturer's Stocks: Disappearance ($X10^8$)	$Z_{12,1}$ Acres Fresh Vegetables Previous Year (Acres $X10^3$)	$Z_{13,1}$ Production Processed Vegetables Prev. Year (Tons $X10^3$)	$\frac{Y_{11}}{Y_{22}}_{-2}$ Lagged Price Ratio Wheat/ Feed Grains	$\frac{Y_{22}}{Y_{11}}_{-1}$ Lagged Price Feed Grain / Wheat (1910-14=1000)	Y_{62-1} Price Eggs Dec. 15 (Cents / dozen)
1929	140	1234	989	988	1088	43
1930	164	1382	1181	969	997	46
1931	213	1533	1375	787	1225	27
1932	269	1572	1117	610	1270	26
1933	276	1631	779	651	915	28
1934	284	1537	894	1409	878	22
1935	257	1728	1153	1494	1267	27
1936	215	1696	1454	1180	924	29
1937	190	1793	1364	1144	1271	31
1938	218	1710	1562	945	848	26
1939	224	1751	1394	809	1058	28
1940	227	1927	1155	933	1021	21
1941	214	1861	1400	983	1116	27
1942	186	1829	1656	1140	1001	34
1943	164	1798	1978	1156	1041	40
1944	138	1733	1929	1139	1115	45
1945	169	2055	1940	1058	1036	45
1946	179	2066	1919	1020	1037	48
1947	190	2219	2058	1111	1056	47
1948	184	2001	1868	1151	1212	59
1949	197	1973	1699	942	889	53
1950	205	2138	1741	962	828	41
1951	193	2165	1615	1117	962	58
1952	204	1975	1868	1155	991	51
1953	235	2016	1815	1080	945	47
1954	231	2129	1811	1033	891	33
1955	265	2159	1743	1094	842	47

Year	$Y_{78_{-1}}$ Price Broilers Previous Year (Cents/lb.)	$Y_{82_{-1}}$ Price of Soybeans For Previous Year (Cents/Bus.)	$Y_{87_{-1}}$ Soybean Acreage Previous Year (Acres X10^{4})	Y_{83}' Price Cotton-seed oil (Cents/lb.)	Y_{84}' Price of Cotton-seed Meal (Crude) (Cents/Ton X10^{-1})	$Y_{83_{-1}}$ Higher Support Price or Previous Year Price of Cotton (Cents X10^{3})
1929	33	188	58	729	367	1798
1930	34	188	71	641	266	1678
1931	30	137	107	319	137	946
1932	26	50	114	351	158	566
1933	15	54	100	407	217	1000
1934	15	94	104	848	323	1200
1935	19	99	156	863	224	1234
1936	20	73	292	915	344	1109
1937	20	127	236	660	224	1236
1938	21	85	259	596	222	860
1939	19	67	304	564	276	895
1940	17	81	432	654	267	915
1941	17	90	481	1227	366	1422
1942	18	155	589	1275	379	1722
1943	23	161	989	1275	486	1926
1944	29	181	1040	1275	485	2108
1945	29	205	1025	1275	551	2109
1946	30	208	1074	2478	746	2438
1947	33	257	993	2625	868	3264
1948	32	333	1141	1542	633	3193
1949	36	227	1068	1261	632	3038
1950	28	216	1048	2039	777	2945
1951	27	247	1381	1298	839	4007
1952	29	273	1355	1425	777	3788
1953	29	272	1434	1356	649	3459
1954	27	272	1483	1340	642	3506
1955	23	246	1705	1300	549	3512

Year	$Y_{97,t-1}$ Acreage Allotted to Cotton or Previous Year Acreage (Acres X10⁴)	$Y_{11,t-1}$ Higher of Support Price of Prices of Previous Year For Burley Tobacco (Cents/lb. X10)'	$Y_{12,t-1}$ Price Previous Year Fresh Vegetables (Dollars/ton X10⁻¹)	$Y_{13,t-1}$ Price Processed Vegetables Previous Year (Dollars/ton X10⁻¹)
1929	4373	306	428	216
1930	4445	218	400	210
1931	4333	155	361	213
1932	3911	87	317	177
1933	3649	125	253	130
1934	3038	105	292	152
1935	2786	169	285	157
1936	2806	191	314	166
1937	3063	357	321	172
1938	2749	201	338	184
1939	2786	190	279	178
1940	2754	173	312	163
1941	2740	200	324	171
1942	2728	292	422	195
1943	2720	418	521	263
1944	2190	456	810	359
1945	1996	440	658	365
1946	1753	394	743	382
1947	1816	403	638	399
1948	2156	485	781	383
1949	2325	460	712	396
1950	2100	457	715	385
1951	1863	498	634	395
1952	2815	512	796	429
1953	2719	503	893	411
1954	2138		727	
1955	1811		709	

SOURCES OF DATA

Y_{11}: Production of wheat.

K. W. Meinken, The Demand and Price Structure For Wheat, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C. Technical Bulletin 1136, November, 1955; and Wheat Situation, WS-149 United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., June, 1956.

Y_{12}: Price of wheat.

Grain and Feed Statistics Through 1954, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., Statistical Bulletin Number 159, March 1955.

Y_{13}: Acreage planted to all wheat or amount of wheat allotments when in effect.

Agricultural Statistics, 1952-55, and Wheat Situation WS-149, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C.

Y_{15}: Wheat used domestically for food, feed, seed and industrial purposes.

Grain and Feed Statistics Through 1954, and Wheat Situation WS-149, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C.

Y_{16}: July 1st year end carry-over of wheat, not under government loan.

Grain and Feed Statistics Through 1954, and Wheat Situation WS-149, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C.

Y_{17}: Quantity of wheat delivered to Commodity Credit Corporation.

Wheat Situation, WS-149, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., June 29, 1956.

Z_{18}: Fertilizer applied in North Dakota and Kansas.

K. W. Meinken, The Demand and Price Structure For Wheat, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C. Technical Bulletin 1136, November 1955.

Z_{13}: Unharvested acreage of wheat.

Agricultural Statistics 1952-55, United States Department of Agriculture, Washington, D. C.

Z_{14}: Net exports of wheat.

K. W. Meinken, The Demand and Price Structure For Wheat, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C. Technical Bulletin 1136, November 1955.

Z_{15}: Acreage planted to winter wheat.

Wheat Situation WS-148, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., April 27, 1956.

Z_{16}: National average support price for wheat.

K. W. Meinken, The Demand and Price Structure For Wheat, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C. Technical Bulletin 1136, November 1955.

Y_{21}: Production of feed grains.

Grain and Feed Statistics Through 1954. United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., Statistical Bulletin Number 159, March 1955.

Y_{22}: Price index for feed grains.

Grain and Feed Statistics through 1954. United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., Statistical Bulletin Number 159, March 1955.

Y_{23}: Amount of feed grains used commercially.

Grain and Feed Statistics Through 1954. United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., Statistical Bulletin Number 159, March 1955.

Y_{24}: Amount of feed grains placed under government loan or purchase agreement.

Grain and Feed Statistics Through 1954. United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., Statistical Bulletin Number 159, March 1955.

Y_{25}: Amount of feed grains placed in farm storage exclusive of government stocks.

<u>Grain and Feed Statistics Through 1954</u>. United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., Statistical Bulletin Number 159, March 1955.

Y_{26}: Planted acreage of feed grains.

<u>Grain and Feed Statistics Through 1954</u>. United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., Statistical Bulletin Number 159, March 1955.

Z_{21}: Production + net imports + beginning inventory of feed grains = supply available for use.

<u>Grain and Feed Statistics Through 1954</u>. United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., Statistical Bulletin Number 159, March 1955.

Z_{22}: Yield per acre of feed grains during the previous year.

<u>Grain and Feed Statistics Through 1954</u>. United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., Statistical Bulletin Number 159, March 1955.

Z_{23}: Unharvested acreage of feed grains during the current year.

<u>Grain and Feed Statistics Through 1954</u>. United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., Statistical Bulletin Number 159, March 1955.

Z_{24}: Index of the number of tractors and combines on farms.

Interpolated for years 1929, 1931-39. For years 1930, 1940-53 data from <u>Agricultural Statistics, 1955</u>, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C.

Z_{25}: Number of animal units fed on farms beginning October 1st of previous year.

<u>Regional Trends in Livestock Numbers</u>, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., Statistical Bulletin Number 146, August 1954.

Z_{26}: National average support price for corn, 1910-14 = 100.

<u>Grain and Feed Statistics Through 1954</u>. United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., Statistical Bulletin Number 159, March 1955.

Z_{29}: Quantity of fertilizer applied in North Central States.

Agricultural Statistics, 1936-55. United States Department of Agriculture, Washington, D. C.

Z_{30}: Net exports of feed grains.

Grain and Feed Statistics Through 1954. United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., Statistical Bulletin Number 159, March 1955.

Y_{31}: Liveweight slaughter of beef.

United States Department of Agriculture, Agricultural Marketing Service files.

Y_{32}: Price of beef.

United States Department of Agriculture, Agricultural Marketing Service Files.

Z_{34}: Index of range condition.

Agricultural Statistics 1952-55, United States Department of Agriculture, Washington, D. C.

Z_{35}: January 1st inventory of steers and calves.

Agricultural Statistics 1952-55, United States Department of Agriculture, Washington, D. C.

Y_{41}: Milk production on farms.

Dairy Statistics and Related Series, United States Department of Agriculture, Washington, D. C., Statistical Bulletin Number 134, October 1953; and *Agricultural Statistics*, 1955, United States Department of Agriculture, Washington, D. C.

Y_{42}: Average cash returns from combined milk and cream marketings.

Dairy Statistics and Related Series, United States Department of Agriculture, Washington, D. C., Statistical Bulletin Number 134, October 1953; and *Agricultural Statistics*, 1955, United States Department of Agriculture, Washington, D. C.

Z_{41}: Per capita disposable income.

Data computed by solving the Klein-Goldberger model for the years 1929-41, 1946-53.

L. R. Klein and A. S. Goldberger, An Econometric Model of the United States, 1929-1953. North Holland Publishing Company, Amsterdam, 1955. For the years 1942-45 data are from the work-sheets of the above analysis but represent actual rather than computed data.

Z_{42}: Percent of milk used for manufacturing purposes as compared to fluid use.

Dairy Statistics and Related Series, United States Department of Agriculture, Washington, D. C., Statistical Bulletin Number 134, October 1953; and Agricultural Statistics, 1955, United States Department of Agriculture, Washington, D. C.

Z_{43}: Number of dairy herd improvement associations.

Agricultural Statistics 1952-55, United States Department of Agriculture, Washington, D. C.

Z_{44}: Index of pasture condition for the months of May-October.

Agricultural Statistics 1952-55, United States Department of Agriculture, Washington, D. C.

Z_{45}: January 1st inventory of cows and heifers two years old or over.

Agricultural Statistics 1952-55, United States Department of Agriculture, Washington, D. C.

Z_{46}: Change in inventory plus net exports of milk products.

Consumption of Food In the United States 1909-52, United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., Agricultural Handbook Number 62, September 1953.

Z_{47}: Production of oleomargarine.

Agricultural Statistics 1952-55, United States Department of Agriculture, Washington, D. C.

Z_{48}: Average hourly marketing cost for handling food products weighted by retailing, transporting, processing and wholesaling functions.

Data from files of K. Ogren, United States Department of Agriculture, Agricultural Marketing Service, Marketing Research Division, Washington, D. C.

X_{51}: Liveweight slaughter of hogs.

Data from files of E. E. Miller, Analytical Statistician, Agricultural Marketing Service, United States Department of Agriculture, Washington, D. C.

X_{52}: Price of hogs.

Agricultural Statistics, 1952 and Livestock and Meat Situation LMS-76, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C.

Z_{53}: January 1st inventory of sows and gilts.

Agricultural Statistics 1952-55, United States Department of Agriculture, Washington, D. C.

X_{61}: Production of eggs.

Agricultural Statistics 1952-55, United States Department of Agriculture, Washington, D. C.

X_{62}: Price of eggs.

Agricultural Statistics 1952-55, United States Department of Agriculture, Washington, D. C.

Z_{63}: Number of birds in National Poultry Improvement Association.

Agricultural Statistics 1952-55, United States Department of Agriculture, Washington, D. C.

Z_{64}: January 1st inventory of hens and pullets on farms.

Agricultural Statistics 1952-55, United States Department of Agriculture, Washington, D. C.

X_{62-1}: Price of eggs on December 15 of the previous year.

From files of E. Karpoff, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C.

X_{71}: Liveweight production of broilers, turkeys and chickens.

Agricultural Statistics 1952-55, United States Department of Agriculture, Washington, D. C.

Y_{y2}: Weighted average annual price for poultry meats, with broilers being included for the period 1934-53.

Agricultural Statistics 1952-55, United States Department of Agriculture, Washington, D. C.

Y_{y2-1}: Price of broilers during the previous year 1934-53 and price of chickens 1929-33.

Agricultural Statistics 1952-55, United States Department of Agriculture, Washington, D. C.

Z_{y3}: Eight year moving average of commercial sales of poultry house equipment.

Manufacture and Sale of Farm Equipment and Related Products, United States Department of Commerce, Washington, D. C. annual reports 1929-53. Interpolations made for years 1932-34.

Y_{e1}: Production of soybeans.

Files of Sidney Gershben, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C.

Y_{e2}: Average price of soybeans.

Files of Sidney Gershben, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C.

Y_{e3}: Value of oil per bushel of soybeans.

M. S. Simon, Soybeans, Economic Analysis Relating to Processing, United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., Marketing Research Report Number 35, May 1953; and Fats and Oils Situation, FOS-181, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., November 26, 1956.

Y_{e5}: Amount of soybeans crushed.

M. S. Simon, Soybeans, Economic Analysis Relating to Processing, United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., Marketing Research Report Number 35, May 1953; and Fats and Oils Situation, FOS-181, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., November 27, 1956.

Y_{s7-1}: Soybean acreage harvested during the previous year.

<u>Agricultural Statistics, 1952-1955</u>. United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C.

Z_{s1}: Linear trend variable, 1929 = 0.

Z_{s2}: Number of row crop cultivators on farms.

<u>Agricultural Statistics, 1952-1955</u>, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C.

Z_{s4}: Average July rainfall in state of Illinois.

<u>Agricultural Statistics, 1952-1955</u>, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C.

Z_{s5}: Percentage of soybean oil extracted by the solvent method.

M. S. Simon, <u>Soybeans, Economic Analysis Relating to Processing</u>. United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., Marketing Research Report Number 35, May 1953.

Y_{c1}: Production of cotton.

<u>Statistics on Cotton and Related Data</u>, United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C. Statistical Bulletin Number 99, June, 1951, and <u>Cotton Situation, CS-167</u>, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., November 1956.

Y_{c2}: Price of Cotton.

<u>Statistics on Cotton and Related Data</u>, United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C. Statistical Bulletin Number 99, June, 1951 and <u>Cotton Situation, CS-167</u>, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., November 1956.

Y_{c5}: Mill consumption of cotton.

<u>Cotton Situation, CS-161</u>, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., November, 1955.

Y_{c6}: Ending inventory of cotton in private storage.

<u>Cotton Situation, CS-161</u>, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., November 1955.

Y_{97}: Cotton placed under loan or purchase agreement and not redeemed;

Statistics on Cotton and Related Data, USDA, BAE, Washington, D. C. Statistical Bulletin Number 99, June 1951, and *Supplement for 1955 on Statistics on Cotton and Related Data*, USDA, AMS, Washington, D. C., November, 1955.

Z_{91}: Percent of total cotton acreage grown in California, New Mexico and Arizona.

Statistics on Cotton and Related Data, United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C. Statistical Bulletin Number 99, June, 1951, and *Cotton Situation CS-167*, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., November 1956.

Z_{92}: Yield decline of cotton due to weather and insects.

Statistics on Cotton and Related Data, USDA, BAE, Washington, D. C. Statistical Bulletin Number 99, June 1951 and *Supplement for 1955 on Statistics on Cotton and Related Data*. USDA, AMS, Washington, D. C., November 1955.

Z_{93}: Prices paid index for cotton farmers.

Computed from data gathered for South Piedmont, Mississippi Delta and Texas Black Prairie areas as it is published in *Farm Costs and Returns for Commercial Family-Operated Farms*, United States Department of Agriculture, Agricultural Research Service, Washington, D. C. periodic issues appearing from 1946-55.

Z_{94}: Net exports of cotton.

Cotton Situation, CS-161, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., November, 1955.

Z_{95}: Supply of cotton exclusive of United States of America.

Cotton Situation, CS-161, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., November 1955.

Z_{96}: Beginning inventory of cotton, exclusive of Commodity Credit Corporation stocks.

Cotton Situation, CS-161, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., November 1955.

Z_{e7}: Beginning inventory of cotton under Commodity Credit Corporation loan or ownership.

Cotton Situation, CS-161, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., November 1955.

Z_{e8}: National average support price for cotton.

Statistics on Cotton and Related Data, United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., Statistical Bulletin No. 99, June, 1951, and *Cotton Situation, CS-167,* United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., November 1956.

Z_{e9}: Production of synthetic fibers in the United States.

Cotton Situation, CS-161, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., November 1955.

$Z_{e,11}$: Fertilizer application per acre of cotton.

Statistics on Cotton and Related Data, United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., Statistical Bulletin No. 99, June 1951, and *Supplement for 1955 on Statistics on Cotton and Related Data,* United States Department of Agriculture, Agriculture Marketing Service, Washington, D. C., November 1955.

Y_{e8-1}: Higher of either the price received by farmers for cotton during the previous year or the support price announced for the current year.

Statistics on Cotton and Related Data, United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., Statistical Bulletin No. 99, June, 1951, and *Cotton Situation, CS-167,* United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., November 1956.

Y_{e7-1}: Announced acreage allotments for cotton when in effect, otherwise the acreage in cultivation on July 1st of the previous year.

Production of cotton.

Statistics on Cotton and Related Data, United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., Statistical Bulletin Number 99, June, 1951, and *Cotton Situation, CS-167,* United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., November 1956.

$Y_{10,1_{t-1}}$: Production of flue cured tobacco.

Data from files of A. Conover, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., and <u>Tobacco Situation TS-76</u>, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., June 1956.

$Y_{10,2_{t-1}}$: Average price received by farmers for flue cured tobacco.

Data from Files of A. Conover, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., and <u>Tobacco Situation TS-76</u>, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., June 1956.

$Y_{10,4}$: Quantity of flue cured tobacco placed under loan.

Data from files of A. Conover, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., and <u>Tobacco Situation TS-76</u>, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., June 1956.

$Y_{10,6}$: Commercial demand for flue cured tobacco for domestic and export markets, computed from the identity $Y_{10,6} = Y_{10,1} - Y_{10,4}$.

Data from files of A. Conover, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., and <u>Tobacco Situation TS-76</u>, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., June 1956.

$Z_{10,1}$: Announced acreage allotments for flue cured tobacco when in effect, otherwise the acreage harvested during the previous year.

Data from files of A. Conover, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., and <u>Tobacco Situation TS-76</u>, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., June 1956.

$Z_{10,2}$: Price support level for flue cured tobacco.

Data from files of A. Conover, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., and <u>Tobacco Situation TS-76</u>, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., June 1956.

$Z_{10,6}$: Higher of the announced support price for the current year and the actual price received by farmers during the previous year.

Data from files of A. Conover, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., and Tobacco Situation TS-76, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., June 1956.

$Z_{10,8}$: Time trend, 1929-1.

$Z_{10,9}$: Average rainfall for the month of June in Raleigh, North Carolina.

Weather and Climate in North Carolina, Agricultural Experiment Station, North Carolina State College, Raleigh, North Carolina, Bulletin 396, October, 1955.

$Z_{10,10}$: Ratio of July stocks of year t to domestic disappearance of the crop year preceding July of year t.

Data from files of A. Conover, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., and Tobacco Situation TS-76, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., June 1956.

$Y_{11,1}$: Production of burley tobacco.

Data from files of A. Conover, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., and Tobacco Situation TS-76, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., June 1956.

$Y_{11,2}$: Average price received by farmers for burley tobacco.

Data from files of A. Conover, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., and Tobacco Situation TS-76, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., June, 1956.

$Y_{11,3}$: Quantity of burley purchased by manufacturers; computed from the identity $Y_{11,3} = Y_{11,1} - Y_{11,4}$.

Data from files of A. Conover, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., and Tobacco Situation TS-76, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., June, 1956.

$Y_{11,4}$: Quantity of burley tobacco pledged for loans.

Data from files of A. Conover, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., and Tobacco Situation TS-76, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., June 1956.

$Z_{11,2}$: Acreage alloted for burley when effective, otherwise the acreage harvested during the previous year.

Data from files of A. Conover, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., and Tobacco Situation TS-76, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., June 1956.

$Z_{11,3}$: Average price support level for burley.

Data from files of A. Conover, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., and Tobacco Situation TS-76, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., June, 1956.

$Z_{11,12}$: Ratio of manufacturer's stocks on October 1st, to domestic disappearance during the year.

Data from files of A. Conover, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C. and Tobacco Situation TS-76, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., June 1956.

$Y_{11,2_{-1}}$: Average price received by farmers for burley during the preceding crop year.

Data from files of A. Conover, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., and Tobacco Situation TS-76, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C., June 1956.

$Y_{12,1}$: Production of fresh vegetables.

Agricultural Statistics, 1952-55, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C.

$Y_{12,2}$: Value per ton received by farmers for fresh vegetables, computed as the quotient of total value and total production.

Agricultural Statistics, 1952-55, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C.

$Z_{12,1}$: Acreage harvested of fresh vegetables.

Agricultural Statistics, 1952-55, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C.

$Y_{13,1}$: Production of vegetables for processing.

Vegetables for Commercial Processing, United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., Statistical Bulletin No. 132, June 1953; and, *Agricultural Statistics, 1955*, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C.

$Y_{13,2}$: Value per ton received by farmers for vegetables for processing.

Vegetables for Commercial Processing, United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., Statistical Bulletin No. 132, June 1953; and, *Agricultural Statistics, 1955*, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C.

$Y_{13,2_{-1}}$: Value per ton received by farmers for vegetables for processing for the previous year.

Vegetables for Commercial Processing, United States Department of Agriculture, Bureau of Agricultural Economics, Washington, D. C., Statistical Bulletin No. 132, June 1953; and, *Agricultural Statistics, 1955*, United States Department of Agriculture, Agricultural Marketing Service, Washington, D. C.