

**COWLES COMMISSION  
FOR RESEARCH IN ECONOMICS**

**FIVE - YEAR REPORT  
1942 - 1946**

**THE UNIVERSITY OF CHICAGO**

## FIVE-YEAR REPORT, 1942-1946

The COWLES COMMISSION FOR RESEARCH IN ECONOMICS is a not-for-profit corporation, founded in 1932, for the purpose of conducting and encouraging investigations into economic problems. The results of research by members of the COMMISSION'S staff are published in two series: COWLES COMMISSION MONOGRAPHS in book form, and shorter papers, usually reprints of articles from journals, as COWLES COMMISSION PAPERS, NEW SERIES. The COMMISSION is affiliated with the ECONOMETRIC SOCIETY, an international society for the advancement of economic theory in its relation to statistics and mathematics. There is a close relation between the COMMISSION and the UNIVERSITY OF CHICAGO.

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	CONTENTS	PAGE
I.	Econometric Research - - - - -	2
	I.1. Economic Structure, Path, Policy, and Prediction - - - - -	2
	I.2. Adapting Statistical Tools - - - - -	6
	I.3. Constructing Economic Models - - - - -	9
	I.4. Revising Economic Fundamentals - - - - -	12
	I.5. Problems for Further Study - - - - -	13
II.	Special Studies - - - - -	14
III.	Research Personnel - - - - -	16
IV.	Sarah Frances Hutchinson Cowles Fellowships - -	16
V.	Cowles Commission Seminars - - - - -	16
VI.	Statistical and Econometric Teaching in the Department of Economics of the University of Chicago	18
VII.	Advisory Committee - - - - -	20
VIII.	Grants - - - - -	20
IX.	Offices, Equipment, and Library - - - - -	20
X.	The Econometric Society - - - - -	21
XI.	Publications of the Cowles Commission - - - - -	22
	XI.1. Cowles Commission Monographs - - - - -	22
	XI.2. Cowles Commission Papers, New Series - -	23
XII.	Biographical and Bibliographical Notes - - - - -	24

The main endeavor of the Cowles Commission is to formulate with logical precision economic theories of practical relevance, and to submit them to the test of facts. This task includes the measurement of economic relationships. They can be used to explain business trends and fluctuations, and to estimate in advance the effects of various economic policies of the nation. The required econometric methods (mathematical and, in particular, statistical techniques in the service of economics) are being worked out systematically. At present, they are being tentatively applied to the American economy and its various sectors.

In addition, the Cowles Commission has from time to time studied special subjects of current interest such as the wartime price control (1942-44) and the economics of atomic energy (1946-47), and individual staff members have devoted a part of their time to subjects outside of the general program. One can thus distinguish between the general econometric research program of the Commission and its special studies.

## I. ECONOMETRIC RESEARCH

The statistical testing of economic theories, the measurement of economic relations, and the explanation of business fluctuations observed in the past have an obvious scientific value in themselves. In addition, these studies may prove useful for prediction and policy, especially in that they may provide guidance for steering between inflations and depressions. The meaning of "Economic Structure, Path, Prediction and Policy" will be briefly analyzed in the next pages of this report, where certain other technical terms will also be explained. This logical analysis is followed by the description of the actual econometric work of the Cowles Commission under the following headings: "Adapting Statistical Tools"; "Estimating Structural Relations"; "Revising Economic Fundamentals"; and "Problems for Further Studies."

### I. 1. ECONOMIC STRUCTURE, PATH, POLICY, AND PREDICTION\*

#### A. *Policy and Prediction*

1. Knowledge is called useful if it helps to choose the *best policy* (action).

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\* Paper presented by J. Marschak on January 24, 1947, at Atlantic City before a joint session of the American Economic Association and the Econometric Society, and reprinted here from the *American Economic Review*, Vol. 37, May, 1947, *Proceedings*, pp. 81-84, by permission of the editor.

2. Best policy depends on
  - (a) the things which one values as *goals*; (e.g., for a firm: profit; for a government: national income, or budget surplus, etc.)
  - (b) noncontrolled *conditions* (e.g., for a firm: weather and government policy; for a government: weather)

The best policy is an action that maximizes (a), given (b).
3. To choose the best policy, it is necessary to *predict*
  - (a) the effect of alternative policies under any given noncontrolled conditions;
  - (b) the future noncontrolled conditions.
4. Thus, all *useful knowledge implies prediction*; and knowledge useless at one time may become useful later when new goals and conditions present themselves.
5. In human affairs (but also in large parts of technology), to predict is, in general, to estimate, for given conditions and for a given probability level, a *probable range* of the results of a given policy. This range is wide if the observations are few or subject to large errors, or if structural relations (see *B*) are subject to large random disturbances.

### *B. Stochastic Economic Structure and Path*

6. The probabilistic character of economic prediction is due to the chance ("stochastic") character of "*economic structure*." The latter is defined as a set of "structural relations."
7. Each of the structural relations describes either
  - (a) *human behavior* (of a specified group of people): e.g., consumers' demand depends on their current and past income, assets, prices, and on a "random disturbance," the latter being the aggregate effect of numerous, separately insignificant factors; or
  - (b) *technology*: e.g., crops depend on acreage, labor, fertilizers, humidity, and a random disturbance; or
  - (c) *legal rules*: e.g., price ceilings, tax laws, bank reserve regulations.

*Economic structure* is fully described by these relations provided the character of the random disturbances (their variances, covariances) is given.

8. The number of structural relations must equal the number of economic (or nonautonomous) variables. In addition, structural relations contain *noneconomic* (or autonomous) *vari-*

ables. At any time, the probable range of values that an economic variable can take depends on the following *conditions*:

- (a) the economic structure,
- (b) the values of noneconomic variables.

9. Conditions can be noncontrolled (see 2 and 3 above) or controlled. Policies and controlled conditions are identical. Thus a *policy fixes either some of the structural relations, or some of the noneconomic variables.*

However, *certain government actions may lie outside of government control.*

For example, certain parts of the budget (interest on national debt) are determined by past values of certain variables; and tax rates may reflect political shifts that, in turn, are partly determined by economic conditions at or before election time. Such nonautonomous government actions will not be classified as policies; and relations stating what determines such actions may have to be included among structural relations (possibly using information gathered by political scientists). On the other hand, government policy may consist in deliberately invalidating such relations of the past and in fixing autonomously variables that were previously governed by structural relations.

The deliberate introduction of "*automatisms*" into the economic structure is a particular kind of policy: for example, adopting the legal rule that a change of level of employment and prices by given amounts should be followed by a certain change (stated in advance) in tax rates or public expenditures, with the object of stabilizing employment or prices; or the Bank of England's old rule to raise the discount rate when gold flows out.

10. The *path* that an economic variable follows through time depends therefore

- (a) on the economic structure:
  - (aa) depending on the character of random disturbances, the *probable range of deviations from the most probable path* will be larger or smaller;
  - (ab) the most probable path may show *oscillations* if some of the structural relations are dynamic, e.g., if they contain time lags or rates of change or of acceleration;
- (b) on *noneconomic variables.*

### *C. The Need for Structural Estimation*

11. Predictions for a future period, based on observations during a past period, are of different kinds according as whether both or one or none of the types of conditions 8 (a), (b) changes within and between the two periods. In particular:

12. *If structure is known to remain in the future what it was in the past, and if the noneconomic variables have constant values through both periods, the path of each variable will be*

*predictable* from the past, apart from random disturbances. The problem is analogous to that of weather prediction.

13. *If structure is known to be retained but the noneconomic variables have assumed and are going to assume changing though known values*, it is possible to estimate for each current economic variable its dependence (“*regression*”) on all noneconomic ones and, under certain conditions, on the past (“*lagged*”) economic ones, and to apply this relation to the future. One can thus estimate the effect of policies that consist in controlling certain variables (tax rates, bank reserve ratios).

14. Finally; *if structure is known to change in a given way* (example: introduction of price control), the prediction of the effect of this change requires the *estimation of the original structure*, i.e., of past relations 7(a), (b), (c).

15. Case 14 applies also with regard to the particular policy of introducing “*automatisms*” (see 9 above) of the most effective kind. For example, to fix in advance the best possible schedule relating tax rates to the unemployment and prices of the previous month, it is necessary to know the lags and elasticities in the consumption equation and in other structural relations at a time when no such legal schedules were in operation. Only when such new device has operated long enough may structural estimation be replaced by the more “*mechanical*” type of predictions described in 12 and 13.

#### *D. Economic Theory, Statistics, and Mathematics*

16. The statistical estimation of the structural relations 7(a), (b), (c) is the “*filling of empty boxes of economic theory.*” The theory is a set of hypotheses. Most of these hypotheses state which variables enter which structural equations, or state certain inequalities (e.g., regarding the signs or relative sizes of certain elasticities). This is based, essentially, on experience independent of the material that is to be used in estimation. This experience may include statements on rational (i.e., utility-maximizing) behavior and on deviations from it; on a plausible psychology of anticipations; on technological data; etc.

17. *Economic theory is useful in the case 14 and useless in the cases 12 and 13.* It can be presumed, however, that cases 12 and 13 seldom occur in practice. In particular, any *policy* that changes one or more of the structural relations of the past gives rise to case 14, and necessitates structural estimation for prediction purposes. Structural estimation may seem useless until a

structural change is expected or intended: it comes in very useful then.

Thus practice requires theory.

18. All the foregoing statements are concerned with the logic of economic knowledge and its uses. *This logic is the same whether or not mathematical symbols are used.* However, mathematical presentation is of great help in testing the internal consistency of a theory (see 8 on the number of relations and variables); and it is hardly avoidable when the *appropriate statistical estimation methods* are to be chosen and applied.

19. After stating the hypotheses about the structure, one may find that a certain aggregate of data will permit prediction only in the form of such a wide range of values as to make it useless for policy choice (since widely differing policies will appear to yield equally good results). For this, mathematics cannot be blamed: it will merely reveal what otherwise might remain concealed. *Mathematics does not suppress any information* available for other methods; and it makes clearer when and how additional information must be used (e.g., extending time series, supplementing them by cross-section data such as attitude surveys, etc.).

## I.2. ADAPTING STATISTICAL TOOLS

If economic experiments were possible, estimating the effects of a given policy would not require any new methods of statistical inference. But to use nonexperimental data—such as the time series of economics, or, for that matter, of meteorology—new methods are needed. The need for a revision of statistical methods when applied to economics has been felt, more or less vaguely, for a long time: ever since Marshall pointed out (1890) the “disturbing causes” that make it difficult to estimate the elasticity of demand; or at least since Pigou showed (1920) that the positive correlation between the quantity and the price of pig iron calculated by Henry L. Moore could not possibly be interpreted as characterizing a “demand curve,” i.e., the behavior of buyers. These “pitfalls in the statistical analysis of demand and supply” (Ragnar Frisch) are due to the nature of economic data that are generated by the interplay of simultaneous structural relations (e.g., demand, or behavior of buyers; supply, or behavior of sellers) and not only by impressed (“autonomous”) forces—such as the environment or the experimenter. Traditional statistical methods have to be revised accordingly, and the Cowles



Commission has applied itself to the task of revision. The problem of prediction and structural estimation must be studied in the light of the modern theory of statistical inference. This implies formulating economic structural relations in probability terms. The problems involved are indicated by the titles of the following papers, completed during the report period:\*

1. "Stochastic Models of Economic Fluctuations" (Hurwicz).
2. "The Probability Approach in Econometrics" (Haavelmo).
3. "Random Simultaneous Equations and the Theory of Production" (Marschak and Andrews).
4. "Statistical Estimation of Simultaneous Economic Relations" (Koopmans).
5. "Estimating Relations from Nonexperimental Observations":  
    "The Economist's Problem of Statistical Inference" (Marschak).  
    "Sampling Aspects of Structural Estimation and Prediction" (Hurwicz).  
    "Iterative Computation Methods in Estimating Simultaneous Relations" (Koopmans and Leipnik).
6. "Methods of Measuring the Marginal Propensity to Consume" (Haavelmo).
7. "Statistical Analysis of Demand for Food: Examples of Simultaneous Estimation of Structural Equations" (Haavelmo and Girshick).
8. "Quantitative Research in Agricultural Economics" (Haavelmo).
9. "Distribution of the Serial Correlation Coefficient in a Circularly Correlated Universe" (Leipnik).
10. "Review of Kendall's book, *Contributions to the Study of Oscillatory Time Series*" (T. W. Anderson).
11. "Alternative Estimates of Period Length for Oscillatory Time Series" (T. W. Anderson).
12. "Estimation of the Parameters of a Single Stochastic Difference Equation in a Complete System" (T. W. Anderson and Rubin).
13. "Accuracy in the Doolittle Solution" (Leavens).

A collection of articles on "Statistical Inference in Dynamic Economic Models," edited by Koopmans, was completed by the end of 1946 and will be published as Cowles Commission Monograph No. 10. It contains contributions by staff members and by other statisticians who were guests at a Cowles Commission Conference in January, 1945. The outline of the Monograph is as follows:

#### INTRODUCTION

##### I. The Distinct Character of Statistical Economics: An Introduction (Marschak)

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\* The first five items are listed in Section XI. 2 as Cowles Commission Papers, New Series, Nos. 3,4,5,11, and 17. Other items have been accepted for publication in various journals and may be reprinted later as Cowles Commission Papers.

**PART ONE: SIMULTANEOUS EQUATION SYSTEMS**

**II. Measuring the Equation Systems of Dynamic Economics (Koopmans, Rubin, and Leipnik)**

This article has the following sections:

1. Description of the Systems Considered
2. Identification of the Economic Relations
3. Estimation of the Parameters
4. Computation of the Maximum-Likelihood Estimates

*Problems of Identification*

**III. Note on the Identification of Economic Relations (A. Wald)**

**IV. Generalization of the Concept of Identification (Hurwicz)**

**V. Remarks on Frisch's Confluence Analysis and Its Use in Econometrics (Haavelmo)**

*Problems of Structural and Predictive Estimation*

**VI. Prediction under Unchanged Structure and the Method of Least Squares (Hurwicz)**

**VII. The Equivalence of Maximum-Likelihood and Least-Squares Estimates of the Regression Coefficients (Koopmans)**

**VIII. Remarks on the Estimation of Unknown Parameters in Incomplete Systems of Equations (A. Wald)**

**IX. Estimation of a Single Equation by the Reduced-Form Method (T. W. Anderson)**

*Problems of Estimation*

**X. Some Computational Devices (H. Hotelling)**

**PART TWO: PROBLEMS SPECIFIC TO TIME SERIES**

*Trend and Seasonal*

**XI. Variable Parameters in Stochastic Processes: Trend and Seasonality (Hurwicz)**

**XII. Nonparametric Tests Against Trend (H. B. Mann)**

**XIII. Tests of Significance in Time-Series Analysis (R. L. Anderson)**

*Estimation Problems*

**XIV. Consistency of Maximum-Likelihood Estimates in the "Explosive" Case (Rubin)**

**XV. Least-Squares Bias in Time Series (Hurwicz)**

*Continuous Stochastic Processes*

**XVI. Models Involving a Continuous Time Variable (Koopmans)**

**PART THREE: SPECIFICATION OF HYPOTHESES**

**XVII. When Is an Equation System Complete for Statistical Purposes? (Koopmans)**

**XVIII. Systems with Nonadditive Disturbances (Hurwicz)**

**XIX. Note on Random Coefficients (Rubin)**

A second conference on methods took place in September, 1946, when the following mimeographed papers were discussed:

a. "Multiequational Hypotheses and the Role of Experiment and Decision" (Marschak).

b. "Statistical Models with Disturbances in Equations and/or Disturbances in Variables" (Hurwicz and T. W. Anderson).

- c. "Estimation of a Single Equation by Means of the Reduced-Form Method" (T. W. Anderson).
- d. "Models Involving a Continuous Time Variable" (Koopmans).
- e. "A Sketch of Results on Small-Sample Confidence Regions" (T. W. Anderson, Hurwicz, Rubin).
- f. "Remarks on Cowles Commission's Multivariate Problems" (John W. Tukey).
- g. "Some Remarks on Multiple Hypothesis" (Rubin).

Although the solution of these methodological problems has advanced far enough to justify experimenting with actual economic hypotheses and data, much remains to be done. We have to learn, in particular, how to deal with more and more general and realistic hypotheses, and how to make a practical compromise between precision on the one hand, and simplicity and flexibility of computational procedures on the other (see below, I.5).

### I.3. CONSTRUCTING ECONOMIC MODELS

For the numerical estimation of relations constituting the economic structure, statistical data are used. Mere contemplation of data is fruitless unless certain hypotheses about the relations are formulated in advance. These hypotheses are suggested by experience *other* than the particular data to be used in subsequent estimation. Such experience is sometimes called common sense; it is also contained in technological and legal data, or provided by earlier and independent historical or even statistical studies. A part of this experience is expressed in economic theories that are deduced from the fact that certain types of human behavior are rather plausible. However, of the existing writings on modern economic structure — including the literature on the production and distribution of national output, on business cycles, unemployment, or international trade — very few contain clear, logically consistent, and complete hypotheses on structural relations. Yet such hypotheses are necessary before a meaningful analysis can be attempted. We have tried to scrutinize much of the useful existing literature: the major propositions of the modern theory of the firm, the consumer's behavior, the behavior in the money market, etc. The macroeconomic models constructed in the 1930's by Frisch, Kalecki, Tinbergen, and others, the mathematical restatement of certain aspects of Keynes' theories by Hicks and Lange have been helpful in starting our work. Possibly the simplest model is the one discussed, as an illustration of the method, in Haavelmo's paper on "Methods of Measuring the Marginal Propensity to Consume" (quoted above, item 6). This model in-

volves only one structural relation, viz., the relation describing consumers' saving as a function of their current and past income (after taxes), while the entrepreneur's investment and the government receipts and expenditures are considered as autonomous. Owing to the sharper formulation of the hypothesis and to the use of appropriate estimation methods, Haavelmo's results may signify a progress compared with discussions based on similar models in recent years. Yet, realism requires more complicated models. For example, a distinction must be made between houses and other consumers' goods and, possibly, between owner-occupied and rented dwellings, because of different motivations involved in each case. Private investment, instead of being autonomous, may prove to depend on current or past prices, wages, or interest rates. Separate motivations may rule the expansion of plant and the changes of inventories. The behavior of borrowers and lenders must be inserted into the system. Government revenue must be broken down into its factors, e.g., tax rates and the taxable income. And so on. Accordingly, a series of more detailed alternative tentative models (each involving a larger number of relations) has been constructed by Klein. To estimate these relations in a provisional way, he first used the traditional method of regression (in item 16 below). In the meantime, other staff members achieved progress with the revision of statistical methods discussed in Section I.2 above. New computational techniques were then tried out, and revised estimates for economic structural relations were prepared. The economic hypotheses themselves are being constantly revised; to use them for forecasting the near future is a way to test them. Much more work will thus be required to get firm ground.

Besides the analysis of the economy as a whole in terms of major aggregates—national income, investment, price level, etc.—there is a need, both scientific and practical, for the analysis of special sectors of the economy. Haavelmo's models for agriculture have been listed above (items 7 and 8, in Section I.2). In these models the behavior of sellers and of buyers in the wholesale and retail food markets are stated and estimated separately, while all other structural relations of the economy are represented by a single relation (which they imply) between current and past national income and certain autonomous variables. This work of Haavelmo was a joint project of the Cowles Commission and the Agricultural Economics Research group of the University of Chicago (D. Gale Johnson, William H. Nicholls, and Theodore W.

Schultz); it owes much to the cooperation with Girshick and to the general support of James Cavin of the U.S. Bureau of Agricultural Economics.

On similar lines, Patinkin attempts a sectional analysis of manufacturing industries.\* This implies in particular a critique of theories of the behavior of entrepreneurs (profit-maximizing or not, competitive or not) that determines output, equipment, inventories, etc. Very likely, time series of national aggregates will have to be supplemented by business records of single firms, and possibly by more intensive sampling of businessmen's attitudes. The practical difficulties that these methods involve may, however, be very great.

Another sectional study, by Sonia Adelson, is devoted to international trade. The foreign trade balance and the international terms of trade, treated as autonomous for purposes of other models, have themselves to be explained. One needs a simplified model of structural relations, which would involve the economies of more than one country but would not treat them in much detail. Jacob Hartog, a Rockefeller Fellow and guest of the Cowles Commission, has also been associated with this subject.

The titles of the following papers, completed during the period covered by the report, indicate the content of our work devoted to the criticism, construction and use of economic models:†

14. "Cross Section of Business Cycle Discussion" (Marschak).
15. "Multiplier Effects of a Balanced Budget" (Haavelmo).
16. "Economic Fluctuations in the U.S. 1920-1941" (Klein), mimeographed. 67 pages. Abstract of this paper was presented at the meeting of Econometric Society, on January 24, 1946, in Cleveland (see *Econometrica*, Vol. 14, April, 1946 pp. 159-162).
17. "A Post-Mortem on Transition Predictions of National Income" (Klein).
18. "Forecasting National Product and Employment" (Klein).
19. "The Use of Econometric Models as a Guide to Economic Policy" (Klein).
20. "Market Adjustment and Inventory Equations" (Patinkin), mimeographed.
21. "Preliminary Model for Manufacturing in the U.S." (Patinkin), mimeographed.

\* Earlier work, by Marschak, Andrews, and Tekiner was mentioned in the *Annual Reports* for 1943, 1944, and 1945.

† The methodological items 3, 6, 7, 8 quoted in Section I.2 should also be mentioned here as each of these articles uses some economic model, at least for illustrative purposes. Items 14, 15, 17 are listed below in Section XI.2 as Cowles Commission papers, New Series, Nos. 9, 12, and 18. Other items have been accepted for publication in various journals, unless marked as mimeographed; they may be later reprinted as Cowles Commission Papers.

#### I.4. REVISING ECONOMIC FUNDAMENTALS

In postulating structural economic relations that have to be submitted to the statistical procedures of testing or estimation, one possibility is to accept, as a first approximation, the assumption of rational economic theory: that people behave so as to maximize their profits (or, more generally, their satisfaction) according to the best knowledge they have. When trying to make use of theory for econometric purposes, one soon discovers, however, that much clarification is required to give the hypotheses a form amenable to statistical tests. In particular, behavior in conditions of uncertainty has only just begun to be analyzed by students of investment. What is the rational behavior for a firm that has only imperfect information, e.g., only a finite sample, from which to estimate the properties of its future product or of its future market? Or, if the firm does not use its imperfect information in the way that the rational statistician would advise it to follow, what are the most plausible psychological patterns according to which modern man's expectations of the future are based on current and past information? What behavior can be predicted when a seller faces only a small number of competitors and buyers? Finally: given a theory of behavior (rational or not) of single individuals in the markets for single commodities, what is the best method of combining these innumerable atomistic structural relations into a useful system of relations between national aggregates—total income, savings, profits, employment, price and wage level, interest rate, etc. Such a system must be both manageable and accurate enough to be applied in prediction and policy decisions. Inasmuch as construction of economic models and estimation of structural relations (Section I.3) has so far proceeded without waiting for complete answers to fundamental problems of economic behavior, the work has been on a somewhat intuitive basis. To improve our theoretical postulates means revising basic economics. The type of problems in question is indicated by the titles of the following papers:\*

22. "The Theory of Economic Behavior" (Hurwicz).
23. "Neumann's and Morgenstern's New Approach to Static Economics" (Marschak).
24. "Macroeconomics and the Theory of Rational Behavior" (Klein).
25. "Theory of the Firm and of Investment" (Hurwicz).
26. "Remarks on the Theory of Aggregation" (Klein).

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\* The first four items are listed below in Section XI.2, being reprinted in Cowles Commission Papers, New Series, Nos. 13, 14, 16. The last item was published in *Econometrica*, Vol. 14, October, 1946, pp. 303-312, and will be later reprinted as a part of a Cowles Commission Paper.

## I. 5. PROBLEMS FOR FURTHER STUDY

The adaptation of statistical tools to econometric analysis will require further work. More data will be needed to reduce the range of error in estimates. In particular, in order to add information contained in quarterly (and perhaps monthly) instead of annual data, we have to find suitable methods of treating seasonal effects and of allowing for correlation between the random disturbances occurring in successive months or quarters. Furthermore, in many cases it is possible, or even necessary, to combine time series with "cross-section" data (e.g., surveys of households or firms). Finally, constant criticism of past estimates in the light of recent data will be extremely useful.

Optimal methods should extract from the data the maximum amount of relevant information that can be obtained through computationally feasible procedures. Computational labor can be reduced if only those structural relations are estimated that are deemed relevant to specific policies under discussion; yet the loss of precision in so doing is to be investigated. To increase the amount of information gained by a given amount of effort we shall also have to devise flexible methods of computation, so that several alternative hypotheses can be used simultaneously. It has been stated above (I.3) that estimation of structural relations requires a certain minimum of hypotheses that are not verifiable from the particular data used for such estimation. However, hypotheses additional to this minimum are amenable to statistical test; at the same time they contribute to the precision of estimates. A statistical theory should be developed that would guide the selection of such additional hypotheses.

The type of hypotheses used has been limited so far to simple cases. The structural relations were assumed linear. The probabilistic character of the estimates was assumed to be due to (additive) random disturbances in relations, while observation errors in variables have been neglected (other investigators have often made the opposite assumption). These assumptions will have to be relaxed or modified in due course. Finally, if known methods are applied to structural relations that involve time lags, estimation biases arise that are negligible only in larger samples than those available at present in the form of time series of annual economic observations (20 years or so). The sampling theory related to "medium-size" time series is a matter for further study.

The revision of economic theories and construction of eco-

conomic models also requires further study of a number of fundamental problems. What are the optimal methods of aggregation—i.e., the most suitable techniques of forming averages (“index numbers”) which would bring the theory of single firms and households to bear upon the political economy of a nation? How should rational economics of the behavior of single firms and households be developed or corrected to become realistic in conditions of uncertainty? What is the size of error committed in treating all governmental actions (e.g., the setting of tax rates) as independent of economic conditions; or, alternatively, how can the dependence of such actions on economic conditions be described in quantitative terms?

As indicated, it will, in general, not be necessary to estimate the whole system of structural relations in order to estimate the results of policies under discussion. To arrange the economic and statistical studies in the order of practical priorities, a systematic classification of policies will be necessary. Policies can be classified according to goals (e.g., high income, stable income, income equalization) or according to formal criteria: some policies consist in discarding certain structural relations and substituting others; some policies merely change the numerical value of certain (nonobserved) structural parameters such as the elasticities of demand or of production; still others change the (observed) values of autonomous variables.

Still further problems loom on the horizon. While trying to explain, or to devise possible controls of, business fluctuations one should not forget the secular trends and the long-run effects of technological, demographic, or institutional changes. In fact, business-cycle policies may be regarded as a special case of general welfare economics which aims at the goal of high employment together with the goal of the best possible utilization of resources. While some thinking on these lines is being done within the Cowles Commission at present, especially in connection with problems of inventions and of optimal location, it is too early to give a more detailed statement on progress in this field of work.

## II. SPECIAL STUDIES\*

*Stock Market Forecasting.* In a paper of this title, Cowles continued the investigations carried out in the past,† analyzing

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\* See Sections X, XI, and XII for exact titles of publications.

† “Can Stock Market Forecasters Forecast?” by Cowles, *Econometrica*, Vol. 1, July, 1933, pp. 309-324; “Some A Posteriori Probabilities in Stock Market Action,” by Cowles and Jones, *Econometrica*, Vol. 5, July, 1937, pp. 280-294.



the degree of success of stock forecasting agencies and testing the existence of regularities in the market.

*Applications of General-Equilibrium Theory.* In two monographs (Nos. 7 and 8) by Mosak and by Lange, the general-equilibrium theory, and especially the modern analysis of stability and of rival and complementary goods, is made fruitful in two fields: the theory of international trade and the theory of money (and other assets) and employment. Lange also dealt with related subjects in several articles.

*Price Control and Business.* A monograph (No. 9) by Katona summarizes the results of extensive field studies conducted in 1942-44 by a staff of assistants under his direction and with the sponsorship of the Rockefeller Foundation and of the Price Conference of the National Bureau of Economic Research. Producers and distributors of consumers' goods in the Chicago area were interviewed by the "open-end question" method, and their attitudes toward price control recorded and analyzed. The study has probably contributed to the fund of experience relating to the use of interview methods for economic research (after leaving the Cowles Commission the author has continued to develop and apply the "open-end question" method for economic surveys on behalf of other institutions).

*Transportation and location.* Koopmans is engaged in a study of the economics of transportation, especially shipping and railroads. The marginal cost of transportation on a given route is derived from a study of the most economic routing of empty equipment from points of discharge to points of loading. Principles are formulated for a system of freight rates expressing marginal cost. The optimal locational distribution of industry in a country requires a rate system of this kind, so as to induce a more balanced use of the transportation equipment than can be obtained through rates depending on distance only.

*Silver.* Leavens continued to collect material on the monetary use and general economics of silver and published articles on the subject.

*Econometrics and ancient history.* Davis continued his work on construction and interpretation of price series for Alexandria and for the late Roman period.

*Mathematical Tables.* Davis continued his work in the preparation of tables of mathematical functions; he also studied the history of these functions and reviewed a number of existing tables.

*Economic effects of atomic energy as a source of power.* This exploratory study was begun in October, 1946, and is sponsored by the Social Science Research Council (Committee on Social Aspects of Atomic Energy, under the Chairmanship of Winfield W. Riefler) and the Rockefeller Foundation. It is intended to list the possible effects that moderately priced electricity produced from a fuel with negligible transportation costs may have on world economy. Codirectors of the study are Marschak and Schurr, assisted by Boorstein and Perazich.

### III. RESEARCH PERSONNEL

Since 1945 the duties of research personnel have been redefined as follows: research associates devote most of their time to the work with the Cowles Commission, aided by full-time or half-time research assistants. Research consultants cooperate in the work of the Commission by participating in staff meetings, by correspondence, or by other occasional contributions. Only active members will be kept at any time on the personnel list such as the list on the cover of this report.

Some of the staff members are members of the Department of Economics. Certain other staff members have been granted the rank of assistant professor or instructor at the University of Chicago by the University's Board of Trustees.

The biographies and brief surveys of activities of research staff are given in Section XII.

### IV. SARAH FRANCES HUTCHINSON COWLES FELLOWSHIPS

Two graduate Fellowships for women were awarded by the University of Chicago upon nomination by the Cowles Commission. Applicants were required to be preparing for the degree of Master of Arts or Doctor in the fields of Social Sciences and Statistics, with preference to be given to students who would be working on quantitative economics or mathematical statistics.

The Fellowships were awarded for the first time in 1946-47 to Sonia Adelson and Selma Schweitzer.

### V. COWLES COMMISSION SEMINARS

Seminars for faculty members, graduate students, and others interested in the studies of the Cowles Commission were

started in July, 1943. The following papers were presented and discussed:

1943

July 6. LEONID HURWICZ, "The Study of Price Determination."

July 22. GERHARD TINTNER, Iowa State College, "Verification of a Simplified Theory of Business Cycles."

September 29. GEORGE KATONA, "The Study of Price Control and Rationing."

November 3. Members of the study group on Price Control and Rationing discussed various aspects of the study then in progress. Speakers were: ROLF A. WEIL, MARVIN L. BRAUDE, and JACK LETICHE.

November 26. The discussion of price control and rationing was continued. The speakers were: SYLVIA M. KAFKA, GEORGE KATONA, and JACK LETICHE. Lt. (j.g.) MARTIN HILBY, U.S.N.R. (formerly of OPA) and Professor THEODORE W. SCHULTZ also participated.

December 13. TJALLING KOOPMANS, Statistician of the Combined Shipping Adjustment Board, "Dynamic Economic Systems."

1944

January 31. CLARK WARBURTON, Principal Economist, Division of Research and Statistics, Federal Deposit Insurance Corporation, "Theories of Monetary Control and the Need for a Responsible Monetary Authority."

February 1 (joint session with Department of Mathematics). ABRAHAM WALD, Associate Professor of Economics, Columbia University, "Statistical Inference."

December 8. "Econometrics of Investment," discussion with Professor JACOB VINER.

1945

May 25, 26. JOHN VON NEUMANN, Professor of Mathematics, Institute for Advanced Study, "Theory of Games and Economic Behavior."

October 15. LAWRENCE R. KLEIN, "Index Numbers and the Theory of Rational Behavior."

October 22. TRYGVE HAAVELMO, "Multiplier Effects of a Balanced Budget."

October 29. JACOB VINER, Professor of Economics, The University of Chicago, "Discussion of Trygve Haavelmo's 'The Probability Approach in Econometrics'" (supplement to *Econometrica*, Vol. 12, July, 1944, Cowles Commission Papers, New Series, No. 4).

November 19. DONALD M. FORT, The University of Chicago, "Modified Keynesian Theory."

November 26. RICHARD STONE, Director, Department of Applied Economics, University of Cambridge, "National Income and Social Accounting."

December 10. W. EDWARDS DEMING, Bureau of the Budget, Washington, D. C., "On Some Criteria of Sampling, with an Illustration in Population Sampling."

December 17. GEORGE KATONA, Division of Program Surveys, Bureau of Agricultural Economics, U.S. Department of Agriculture, "Wartime Savings and Their Effects."

1946

January 8. LEONID HURWICZ, "Analysis of the Economic Stagnation Thesis."

January 22. THEODORE W. ANDERSON, JR., "Statistical Tests of Rank and Estimation of the Linear Relations between Expected Values."

February 5. ROY B. LEIPNIK, "Distribution of the Serial Correlation Coefficient."

February 19. H. GREGG LEWIS, "Some Problems in the Analysis of Demand for Steel."

March 19. TRYGVE HAAVELMO, "Analysis of Demand for Agricultural Products."

April 2. LEONID HURWICZ, "Theory of the Firm and of Investment."

April 17. LAWRENCE R. KLEIN, "National Product Forecasts for the Reconversion Period."

May 1. WALTER BARTKY, Dean of the Division of Physical Sciences, "Recent Applications of Statistics in Physical Science."

May 22. EVERETT R. HAGEN, Office of War Mobilization and Reconversion, "Forecasting National Product and Employment."

June 3. JAN TINBERGEN, Professor of Statistics, Rotterdam School of Economics, "Discontinuous Functions in Economics."

June 4. JAN TINBERGEN, "Theory of Speculative Demand for Raw Materials."

October 9. E. J. WORKING, Professor of Agricultural Economics, University of Illinois, "What Would Prices Have Been Without Controls? Can Statistical Analyses of Demand Tell Us?"

October 26. J. R. HICKS, Professor of Economics, University of Oxford, "The Aggregation of Consumers' Surplus."

November 6. DOROTHY S. BRADY, Chief, Cost of Living Division, Bureau of Labor Statistics, U. S. Department of Labor, "Interpretation of Consumption Data in the Derivation of Standard Budgets."

November 21. TRYGVE HAAVELMO, "Econometric Methods and Agricultural Policy."

December 5. KENNETH MAY, "Tentative Methods of Dealing with Technological Change."

## VI. STATISTICAL AND ECONOMETRIC TEACHING IN THE DEPARTMENT OF ECONOMICS OF THE UNIVERSITY OF CHICAGO

Staff members of the Cowles Commission participate in the teaching activities of the University of Chicago, especially in the field of statistics and economic theory. Stress is laid upon the connection among mathematics, economics, and statistics. The following courses are listed (but not all are given every year):

INTRODUCTION TO STATISTICS. Elementary principles of statistics. Main topics: frequency distributions, averages, dispersion and skewness, time series, index numbers, simple correlation, elements of sampling, and statistical inference.

**STATISTICAL INFERENCE** (two two-course sequences). A survey of the principles of statistical inference, with emphasis on the techniques useful in applying these principles to the analysis of social, economic, and business data. Among the subjects treated will be: elements of probability; concepts of population, sample, and sampling distribution; choice of estimates in the light of their sampling properties; testing hypotheses with reference to specified alternatives; principles of sampling and sample design; analysis of proportions, means and standard deviations; simple, partial, and multiple regression and correlation. These courses are given in two sequences covering substantially the same statistical principles and procedures, one section making less use of explicit mathematical formulations than the other.

**INTRODUCTION TO ECONOMETRICS.** Statistical testing of economic theories. Numerical estimation of demand and cost functions and other functions occurring in the theory of the firm and household, the theory of markets, and the theory of national income. Estimation of economic models. Statistical prediction under conditions of changing economic structure and policy.

**STATISTICAL METHODS OF MEASURING ECONOMIC RELATIONS.** Systems of economic relationships. Prediction and structural estimation. Criteria for identifiability, and methods of estimation, of economic relations. Problems connected with time lags.

**APPLICATIONS OF STATISTICAL ANALYSIS.** The content of this course will vary from one year to another, but will concern applications of statistics to business, economic, and social data. For example, members of the class individually or jointly may carry through a statistical investigation; or a series of statistical studies in economics or business may be analyzed in detail; or some special field of application may be studied.

**THE MAIN ECONOMIC MAGNITUDES.** Survey of sources and methods for estimating national income, capital formation, consumption, balance of payments, monetary circulation, and prices. Attention is given to practical work. Students have opportunity to familiarize themselves with the sources and techniques relevant to the statistical study of the American economy.

**INTRODUCTION TO MATHEMATICS FOR ECONOMISTS.** A survey of those parts of mathematical analysis which are used in economics. Fundamental mathematical concepts: function, limits, Dimensions. Elementary Calculus. The application to economics is stressed throughout.

**PROBLEMS IN MATHEMATICAL ECONOMICS.** Elements of advanced calculus and of ordinary and differential equations applied to fundamental economic problems. The material is arranged in the order of increasing mathematical difficulty.

**ECONOMETRICS OF BUSINESS FLUCTUATIONS.** Mathematical formulation and statistical testing of theories of economic change. Growth and fluctuations. Prediction and Policy.

These courses are additional to the relevant courses given in the School of Business and the Departments of Education, Mathematics, Psychology, Sociology, and Zoology.

Staff members of the Cowles Commission are scheduled to give a large part of the courses listed above and of the following courses: **THE DIVISIONAL COURSE IN ECONOMICS**; and **THE THEORY OF INCOME AND EMPLOYMENT**.

## VII. ADVISORY COMMITTEE

The University of Chicago Advisory Committee of the Cowles Commission for Research in Economics meets from time to time to coordinate the work of the Cowles Commission with other research and teaching work of the University. The chairman is Theodore W. Schultz, chairman of the Department of Economics. The vice-chairman is Louis Wirth, Secretary of the Social Science Research Committee of the University.

## VIII. GRANTS

Acknowledgment is made to the Rockefeller Foundation and the Social Science Research Committee of the University of Chicago for financial assistance in the research work of the Cowles Commission. Several of the research staff have held Fellowships from the Guggenheim Foundation, the Social Science Research Council, or the University of Chicago.

## IX. OFFICES, EQUIPMENT, AND LIBRARY

The Cowles Commission occupies rooms provided by the University of Chicago in its Social Science Building, 1126 East 59th Street. There are 6 individual offices, a large room with desks for staff members, also used for staff conferences; a room for secretarial and computing staff, provided with 7 adding and calculating machines, 4 typewriters, and other equipment; and two rooms for library.

The Commission has been building up a library containing most of the material pertinent to its investigations and now has some 1800 books, 3100 pamphlets, and 350 bound volumes of periodicals. In addition, the library of the late Professor Henry Schultz, belonging to the University, is kept in the Commission's offices; it contains 950 books and 1750 pamphlets. About 115 periodicals are received regularly. The library is open to advanced students by arrangement.

## X. THE ECONOMETRIC SOCIETY

The Cowles Commission since its organization in 1932 has been affiliated with the Econometric Society, an international society for the advancement of economic theory in its relation to statistics and mathematics. The Society's offices have been located at the headquarters of the Cowles Commission in Colorado Springs and later in Chicago, and its quarterly journal, *Econometrica*, has been published there. Membership in the Society has

grown from 163 in 1931 to 721 in 1941 and 774 in 1946. Nonmember subscribers to *Econometrica*, chiefly libraries, have increased from 77 in 1933, its first year of publication, to 295 in 1941 and 445 in 1946. Members and subscribers are located in 51 different countries. During the war the office could not communicate with those in many of the belligerent countries, but contact has now been renewed with a good proportion of them. Through 1946, 14 volumes of *Econometrica*, totalling about 5500 pages, have been published.

During the last five years members of the Cowles Commission staff have continued to take an active part in the work of the Society. Marschak served as vice-president in 1944 and 1945 and as president in 1946. Cowles continued as secretary and treasurer throughout the period. Lange was acting editor of *Econometrica* from 1943 to 1945, when it was impossible to communicate with the editor, Ragnar Frisch, of the University of Norway. The following continued to serve during the period covered by this report: Davis, associate editor; Marschak, member of the advisory editorial board; Leavens, managing editor; and Cowles, business manager. Koopmans, Lange, Leavens, and Marschak have served on the program committee for meetings of the Society.

During the war meetings had to be suspended for a time, but one was held at Cleveland, Ohio, September 13-15, 1944, in conjunction with the meeting of the American Association for the Advancement of Science; and another in the same city, January 24-27, 1946, in conjunction with meetings of the American Economic Association, the American Statistical Association, and the Institute of Mathematical Statistics.

## XI. COWLES COMMISSION PUBLICATIONS

### XI.1. COWLES COMMISSION MONOGRAPHS

No. 7. *General-Equilibrium Theory in International Trade*, by JACOB L. MOSAK. Bloomington, Indiana, The Principia Press, 1944. 187 pages.

Part One: Static-Equilibrium Theory in International Trade. I. The Equilibrium of Exchange for an Individual. II. Equilibrium of Exchange in a Closed Economy. III. Equilibrium of Exchange in an International Economy. IV. The Special Case of Two Commodities and Two Countries. V. The General Equilibrium of Production in International Trade.

Part Two: Intertemporal-Equilibrium Theory in International Trade. VI. Individual Consumer Planning. VII. Entrepreneurial Planning. VIII. Market Equilibrium in a Closed Economy. IX. Market Equilibrium in an In-

ternational Economy. X. Conclusion. Bibliography. Index of Names. General Index.

No. 8. *Price Flexibility and Employment*, by OSCAR LANGE. Bloomington, Indiana, The Principia Press, 1944. 114 pages.

I. Introduction. II. Partial-Equilibrium Theory. III. General-Equilibrium Theory. IV. Analysis of the Monetary Effect. V. Price Expectations. VI. Uncertainty. VII. Imperfect Competition. VIII. International Trade. IX. Changes in the Propensity to Consume. X. Changes in the Propensity to Consume (continued). XI. Capital Accumulation and Investment Opportunities. XII. Innovations. XIII. The Problem of Policy. Appendix: The Stability of Economic Equilibrium. Index of Names. General Index.

No. 9. *Price Control and Business*, by GEORGE KATONA. Bloomington, Indiana, The Principia Press, 1945. 246 pages.

Part One: Introduction. I. The Task. II. The Method. III. The Sample. IV. Historical Background.

Part Two: Pricing Procedures under Price Control. V. Legal Direct Price Increases. VI. Illegal Direct Price Increases. VII. Indirect Price Increases: Quality Deterioration. VIII. Reduction in Number and Size of Markdowns. IX. Uptrading: Shift to Better-Grade Merchandise. X. Keeping Prices Stable. XI. Comparison of Pricing Procedures in Different Fields.

Part Three: Factors Favoring or Impeding Price Stability. XII. Type of Regulation. XIII. Rationing as an Aid to Price Control. XIV. The Role of the Market Structure. XV. Wartime Changes in Supply, Demand, Business Volume, and Profits. XVI. Influence of Price Control on Demand. XVII. Businessmen's Attitudes toward Price Control.

Part Four: Changes in the Relative Positions of Different Firms. XVIII. Informal Rationing. XIX. The Wholesale Trade. XX. Small vs. Large Firms. XXI. Chains vs. Independents, Inexpensive vs. Expensive Firms. XXII. Business Initiative under Price Control.

Part Five: Conclusions. XXIII. Interviewing as a Tool of Economic Research. XXIV. Toward an Appraisal of Price Control.

Appendixes: I. The Questionnaires. II. The Sample. III. Sales and Profits. Index of Commodity Lines Discussed. General Index.

## XI.2. COWLES COMMISSION PAPERS, NEW SERIES

At the end of 1943 the policy was adopted of having reprints of papers by members of the Commission's research staff bound in special covers as Cowles Commission Papers, New Series. By the end of 1946 the following had been issued in this series:

No. 1. OSCAR LANGE, "The Theory of the Multiplier," *Econometrica*, Vol. 11, July-October, 1943, pp. 227-245.

No. 2. GEORGE KATONA, "The Role of the Frame of Reference in War and Post-War Economy," *The American Journal of Sociology*, Vol. 49, January, 1944, pp. 340-347.



No. 3. LEONID HURWICZ, "Stochastic Models of Economic Fluctuations," *Econometrica*, Vol. 12, April, 1944, pp. 114-124.

No. 4. TRYGVE HAAVELMO, "The Probability Approach in Econometrics," *Econometrica*, Vol. 12, Supplement, July, 1944, viii + 118 pp. Contents: I. Abstract Models and Reality. II. The Degree of Permanence of Economic Laws. III. Stochastic Schemes as a Basis for Econometrics. IV. The Testing of Hypotheses. V. Problems of Estimation. VI. Problems of Prediction. Conclusion.

No. 5. JACOB MARSCHAK and WILLIAM H. ANDREWS, JR., "Random Simultaneous Equations and the Theory of Production," *Econometrica*, Vol. 12, July-October, 1944, pp. 143-205. Contents: Introduction. I. Hypotheses. II. Statistical Method. III. Data and Findings. IV. Appendix 1: Decreasing, Increasing, and Constant Returns to Scale. V. Appendix 2: Critical Note. VI. Appendix 3: Consistent Estimates of Parameters of Systems of Linear Equations without Time Lags. References.

No. 6. ALFRED COWLES, "Stock Market Forecasting," *Econometrica*, Vol. 12, July-October, 1944, pp. 206-214.

No. 7. GEORGE KATONA and DICKSON H. LEAVENS, "Price Increases and Uprading: The Change in Advertised Prices of Apparel and House Furnishings," *The Journal of Business of the University of Chicago*, Vol. 17, October, 1944, pp. 231-243.

No. 8. OSCAR LANGE, "The Stability of Economic Equilibrium," being Appendix to Cowles Commission Monograph No. 8, *Price Flexibility and Employment*, pp. 91-109.

No. 9. JACOB MARSCHAK, "A Cross Section of Business Cycle Discussion," *American Economic Review*, Vol. 35, June, 1945, pp. 368-381.

No. 10. HERMAN RUBIN, "On the Distribution of the Serial Correlation Coefficient," *Annals of Mathematical Statistics*, Vol. 16, June, 1945, pp. 211-215.

No. 11. TJALLING KOOPMANS, "Statistical Estimation of Simultaneous Economic Relations," *Journal of the American Statistical Association*, Vol. 40, December, 1945, pp. 448-466.

No. 12. TRYGVE HAAVELMO, "Multiplier Effects of a Balanced Budget," *Econometrica*, Vol. 13, October, 1945, pp. 311-318.

No. 13. LEONID HURWICZ and JACOB MARSCHAK, "Games and Economic Behavior, Two Review Articles," *American Economic Review*, Vol. 35, December, 1945, pp. 909-925, and *Journal of Political Economy*, Vol. 54, April, 1946, pp. 97-115.

No. 14. LAWRENCE R. KLEIN, "Macroeconomics and the Theory of Rational Behavior," *Econometrica*, Vol. 14, April, 1946, pp. 93-108.

No. 15. G. HABERLER, R. M. GOODWIN, EVERETT E. HAGEN, and TRYGVE HAAVELMO, "Multiplier Effects of a Balanced Budget, Notes Supplementary to Cowles Commission Papers, New Series, No. 12," *Econometrica*, Vol. 14, April, 1946, pp. 148-158.

No. 16. LEONID HURWICZ, "Theory of the Firm and of Investment," *Econometrica*, Vol. 14, April, 1946, pp. 109-136.

No. 17. JACOB MARSCHAK, LEONID HURWICZ, TJALLING KOOPMANS, and ROY BERGH LEIPNIK, "Estimating Relations from Nonexperimental Observations. Abstracts of Papers Presented at Cleveland, January 25, 1946," *Econometrica*, Vol. 14, April, 1946, pp. 165-172.

No. 18. LAWRENCE R. KLEIN, "A Post-Mortem on Transition Predictions of National Product," *Journal of Political Economy*, Vol. 54, August, 1946, pp. 289-308.

## XII. BIOGRAPHICAL AND BIBLIOGRAPHICAL NOTES

Biographies and brief surveys of the activities of research associates during 1942-1946 and of research consultants and assistants during 1945-1946 follow.

After the biography of each staff member are given first his publications in the series of Cowles Commission Monographs and Papers (for full titles see Section XI), next his other publications, and finally his papers presented orally.

Similar material for earlier years will be found in *Decennial Report, 1932-1941*

### MARIANNE ABELES

Marianne Abeles, fellow of the Department of Economics and candidate for the Ph.D. degree, was a part-time research assistant during the first half of 1946, collecting statistical data for Klein's studies on economic models in the U.S.A.

### THEODORE W. ANDERSON, JR.

Theodore W. Anderson, Jr. (B.S., Northwestern, 1939; M.A., Princeton, 1942, Ph. D., 1945) was a research associate from November, 1945, to September, 1946, when he became an instructor in mathematical statistics at Columbia University, continuing as a research consultant of the Commission.

He was an instructor at Princeton University, 1941-43, and a research mathematician of the Statistical Research Group there, 1943-45. He is the author of several papers on mathematical statistics.

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"The Non-Central Wishart Distribution and Certain Problems of Multivariate Statistics," *Annals of Mathematical Statistics*, Vol. 17, December, 1946, pp. 409-431.

(With M. A. Girshick and H. Rubin) "Estimation of the Parameters of a Single Stochastic Difference Equation in a Complete System," presented at Washington, April 12, 1946, before a joint regional meeting of the Washington Chapters of the Institute of Mathematical Statistics and the American Statistical Association.

(With Herman Rubin) "Estimation of Structural Equations through Linear Transformation of Regression Coefficients," presented at Ithaca, August 23, 1946, before the Institute of Mathematical Statistics (abstract in *Annals of Mathematical Statistics*, Vol. 17, December, 1946, pp. 503-504).

#### WILLIAM H. ANDREWS, JR.

William H. Andrews (B.S., Indiana, 1933, A.M., 1937) was a research associate from July, 1943, to March, 1944, when he became an ensign in the United States Naval Reserve and served in the Pacific.

Andrews was an instructor in economics at Purdue University, 1937-1941, a fellow at the University of Chicago, 1942-1943, and a research associate of the Department of Economics at the University of Chicago, 1943-1944.

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Cowles Commission Papers, New Series, No. 5 (1944).

#### KENNETH J. ARROW

Kenneth J. Arrow (B.S., College of the City of New York, 1940; M.A., Columbia, 1941) joined the staff as a research associate in April, 1947.

Arrow enlisted for aviation cadet training\* in meteorology in October, 1942, and served in various positions in the Weather Division of the Army Air Forces; he was separated from the service in February, 1946, with the rank of Captain. He was an instructor in economics at College of the City of New York, summer session, 1946, and an assistant in statistics, School of Business, Columbia University, in the fall of 1946.

#### EDWARD BOORSTEIN

Edward Boorstein (B.S.S., College of the City of New York, 1936; M.A., Columbia, 1940) joined the staff in the autumn of 1946 as a research associate (with the rank of instructor) in the study of the economics of atomic energy.

Boorstein was economic assistant to the Board of Governors of the Federal Reserve System, 1940-1942; economist, War Production Board, 1942-1943; economist, Civilian Production Administration, 1946.

#### GERSHON COOPER

Gershon Cooper, (A.B., Chicago, 1942), graduate student in the department of economics, assisted Haavelmo in the work on agricultural models, for the joint project of the Agricultural Economics Group and the Cowles Commission mentioned in Section I.3. He began to work on December 1, 1946, on a part-time basis.

#### ALFRED COWLES

Alfred Cowles (B.A., Yale, 1913) founded the Cowles Commission in 1932 and has been its president since the beginning.

For ten years prior to the foundation of the Commission, Cowles maintained a private organization for statistical research on problems pertaining to investment and finance. He is a Fellow of the Econometric Society and its secretary and treasurer, a trustee of Colorado College, and a director or trustee of numerous corporations and philanthropic organizations. He is the author of several papers on stock-market topics.

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Cowles Commission Papers, New Series, No. 6 (1944).

"Stock Market Forecasting," presented at Chicago, October 5, 1943, before the Seminar on the Changing Economy.

"Stock Market Forecasting," presented at Chicago, November 1, 1944, before the Chicago Chapter of the American Statistical Association.

"History of the Cowles Commission," presented at Chicago, July 11, 1945, before the Committee on Instruction and Research of the Board of Trustees of the University of Chicago.

#### FORREST DANSON

Forrest Danson (A.B., Colorado College, 1929) joined the staff of the Commission at its beginning in 1932; in March, 1943, he left to take a statistical position in the Army Air Force Materiel Command at Wright Field, Dayton, Ohio.

Danson was in charge of the computing work of the Commission, and also made various studies of common-stock prices. In 1942-43 he took part in the field work of the study of price control.

#### HAROLD T. DAVIS

Harold T. Davis (A.B., Colorado College, 1915; A.M., Harvard, 1919; Ph.D. Wisconsin, 1926) was a research associate of the Commission from its beginning in 1932, spending several months of each year in the Commission's laboratory while it was at Colorado Springs and consulting by correspondence at other times. From February to August, 1937, he was acting research director. In 1946 he became a research consultant.

Davis was professor of mathematics at Indiana University, 1923-1937, and at Northwestern University since 1937, where he is chairman of the department. He is a Fellow of the Econometric Society. He is the author of numerous books and articles, of which those published since 1932 are listed in this report and in the *Decennial Report, 1932-1941*. He is an associate editor of *Econometrica*, and has served in the same capacity for *Isis* and the *Bulletin of the American Mathematical Society*.

During the years covered by this report he has done extensive work in the construction of mathematical tables and in developing the history and properties of mathematical functions. He has completed the MS of *Alexandria, The Golden City*, which emphasizes the development of mathematics and science in that center; and has been studying the mathematical interpretation of history, assembling materials for the construction of price series for both the Alexandrian and the Roman economies from about 300 B.C. to 400 A.D. A MS entitled *A History of Energy* has just been completed; this is a revision and extensive enlargement of the author's *Philosophy and Modern Science*, Bloomington, Principia Press, 1931.

*College Algebra*, revised and enlarged edition. Prentice-Hall, 1942, xix + 470 pp.

*Outline of An Encyclopedia of Mathematical Functions*, in 20 Volumes, 49 pp. (Mimeographed).

"Review of William Fleetwood Shephard, *The Probability Integral*, and of Project for the Computation of Mathematical Tables, *Tables of Probability Functions*," in *Mathematical Tables and other Aids to Computation*, Vol. 1, April, 1943, pp. 48-51.

"Review of Zaki Mursa, *Tables of Legendre Associated Functions*," *Mathematical Tables and Other Aids to Computation*, Vol. 1, October, 1943, pp. 116-119.

"Review of 'Coefficients for Numerical Differentiation with Central Differences,' by H. E. Salzer," *Mathematical Tables and Other Aids to Computation*, Vol. 1, April, 1944, pp. 186-187.

"Review of 'Table of Fourier Coefficients,' by A. N. Lowan and J. Laderman," *Mathematical Tables and Other Aids to Computation*, Vol. 1, April, 1944, pp. 192-193.

"Review of *Graphical Solutions*, by C. O. Mackey," *National Mathematics Magazine*, Vol. 19, October, 1944, pp. 49-50.

"Review of *Elementary Statistical Methods*, by Helen M. Walker," *National Mathematics Magazine*, Vol. 19, November, 1944, pp. 103-104.

"Archimedes and Mathematics," *School Science and Mathematics*, Vol. 44, 1944, pp. 136-145, 213-221.

"Review of *A Treatise on the Theory of Bessel Functions*, by G. N. Watson," *National Mathematics Magazine*, Vol. 19, December, 1944, pp. 153-154.

"Review of Bateman and Archibald, 'A Guide to Tables of Bessel Functions' (*Mathematical Tables and Other Aids to Computation*, Vol. 1, July, 1944)," *Science*, Vol. 101, January 12, 1945, pp. 39-41.

"Review of British Association for the Advancement of Science, *Mathematical Tables*, Vol. IX, *Table of Powers Giving Integral Powers of Integers*: and of WPA Mathematical Tables Project, *Table of the First Ten Powers of Integers from 1 to 1000*," *Mathematical Tables and Other Aids to Computation*, Vol. 1, January, 1945, pp. 355-356.

"Review of G. W. King, 'Punched-card Tables of Exponential Functions,' (*Review of Scientific Instruments*, Vol. 15, 1944, pp. 349-350); and of G. B. Thomas and G. W. King, 'Preparation of Punched-card Tables of Logarithms' (*ibid.*, p. 350)" *Mathematical Tables and Other Aids to Computation*, Vol. 1, April, 1945, pp. 399-400.

"Review of H. W. Holtappel, *Tafels von  $e^x$* ," *Mathematical Tables and Other Aids to Computation*, Vol. 1, October, 1945, pp. 437-438.

"Review of Friedrich Tölke, *Praktische Funktionenlehre, Erster Band, Elementare und elementare transzendente Funktionen*," *Mathematical Tables and Other Aids to Computation*, Vol. 2, January, 1946, pp. 23-24.

"Review of Karl Stumpf, *Tafeln und Aufgaben zur harmonischen Analyse und Periodogrammrechnung*," *Mathematical Tables and Other Aids to Computation*, Vol. 2, January, 1946, pp. 32-33.

"Review of H. E. Salzer, 'Inverse Interpolation for Eight-, Nine-, Ten-, and Eleven-Point Direct Interpolation,'" *Mathematical Tables and Other Aids to Computation*, Vol. 2, April, 1946, p. 73.

"Review of NYMPT, *Tables of Associated Legendre Functions*," *Mathematical Tables and Other Aids to Computation*, Vol. 2, April, 1946, pp. 79-80.

"Review of NYMPT, *Binomial Distribution Functions*," *Mathematical Tables and Other Aids to Computation*, Vol. 2, July, 1946, pp. 120-121.

"Some Problems in Econometrics," presented at Lake Forest College, March 10, 1942.

"Dinner with Archimedes," presented at Crawfordsville, Indiana, April 24, 1942, before the Indiana Section of the Mathematical Association of America (abstract in *American Mathematical Monthly*, Vol. 49, November, 1942, p. 582). Also presented at Chicago, October, 1942, before the Men's Mathematics Club of Chicago.

"A Mathematical Theory of Income and Its Consequences," presented at Crawfordsville, Indiana, April 25, 1942, before the Indiana Section of the Mathematical Association of America (abstract in *American Mathematical Monthly*, Vol. 49, November, 1942, p. 582).

"Luncheon with Euclid," presented at Evanston, October, 1942, before the Women's Mathematics Club of Chicago.

"Dinner with Cleopatra," presented at Chicago, November 17, 1942, before Phi Delta Kappa.

"Mathematical Patterns in History," presented at Evanston, December 2, 1942, as retiring address of the president of the Northwestern University Chapter of Sigma Xi.

"The Econometric Problem," presented at Evanston, January 19, 1943, before Sigma Delta Epsilon, women's scientific organization of Northwestern University.

"The Saddle-Point Method (Method of Steepest Descents) in Approximation," presented at Ames, May 12, 1943, before the Mathematics Seminar, Iowa State College.

"Serial Correlation," presented at Ames, May 12, 1943, before the Statistical Seminar, Iowa State College.

"Alexandria, the Golden City," presented at Ames, May 13, 1943, before the Graduate School, Iowa State College.

"The Econometric Theory of History," presented at Ames, May 13, 1943, before the Social Science Seminar, Iowa State College.

"The History of Price Movements," presented at Chicago, August 25, 1943, before the Seminar on the Changing Economy.

"Orthogonal Functions," presented at Chicago, October 13, 1943, before the Chicago Chapter of the American Statistical Association.

"Archimedes and Mathematics," presented at Chicago, November 27, 1943, before the Central Association of School Science and Mathematics Teachers, Junior College Section.

"Price Cycles, Past and Present, and Their Significance," presented at Chicago, March 21, 1944, before Phi Delta Kappa, National Educational Fraternity.

"The Saddle-Point Method," presented at Chicago, April 4, 1944, before the Mathematical Club of the University of Chicago.

"Alexandria, the Golden City," presented at Chicago, April 22, 1944, before the Chicago Classical Club.

"Lessons from Alexandria," presented at Ripon College, Ripon, Wisconsin, May 4, 1944.

"The Application of Fractional Operations to a Problem in the Stimulation of Nerves," presented at Chicago, May 12, 1944, before the Mathematical Biophysics Seminar of the University of Chicago.

"Utility and the Thermodynamic Analogue," presented at Chicago, October 27, 1944, before the Mathematical Biophysics Seminar of the University of Chicago.

"Imagination in Mathematics," presented at Chicago, January 16 and 17, 1945, at the University of Chicago in lecture course on "Mathematics and the Imagination."

"Computing as a Fine Art," presented at Chicago, May 18, 1945, before the Men's Mathematical Club of Chicago.

"Some Mathematical Aspects of Atomic Energy," presented at Evanston, October 11, 1945, before Pi Mu Epsilon Mathematical Fraternity of Northwestern University.

"Social Implications of Atomic Energy," presented at Evanston, November 11, 1945, before the Evanston Fireside Forum.

"Mathematics is a Language," presented at Evanston, February 12, 1946, before the Modern Language Seminar of Northwestern University.

"The Distribution of Income in Cicero's Time," presented at Cleveland, January 27, 1946, before the Econometric Society, (abstract in *Econometrica*, Vol. 14, April, 1946, pp. 184-185).

"Some Economic Aspects of Government Debt," presented at Chicago, November 13, 1946, before the Chicago Tax Club.

"The Growth of Power and Its Economic Significance," presented at Detroit, November 29, 1946, before the Central Association of Science and Mathematics Teachers (published in *School Science and Mathematics*, Vol. 47, 1947, pp. 124-138).

#### JOEL DEAN

Joel Dean (A.B., Pomona, 1927; M.B.A., Harvard, 1929; Ph.D., Chicago, 1936) was a research associate from September, 1939. In 1941 he went on leave of absence to become a price executive in the Office of Price Administration, where he later became director of fuel rationing. He was associated with McKinsey & Co. as a management consultant, 1944-1946. In 1944 he was a visiting professor at the School of Business, Columbia University, and in 1945 resigned from the Commission to accept a position as professor of business economics there.

Dean was on the staff of the International Business Machines Corporation, 1930-1932; assistant professor of economics, Indiana University, 1934-1937; management consultant, McKinsey, Wellington and Co., 1937-1938; executive secretary of the Conference on Price Research, National Bureau of Economic Research, 1938-1939; assistant professor of statistics and marketing in the School of Business and director of the Institute of Statistics, the University of Chicago, from 1939 till his resignation in 1945. He is the author of *Statistical Determination of Costs with Special Reference to Marginal Costs*, 1936, and of several articles in statistical and economic journals, chiefly on the subject of costs.

"Direct Control of Machinery Prices," *Harvard Business Review*, Vol. 20, Spring, 1942, pp. 277-289.

(With R. Warren James) *The Long-Run Behavior of Costs in a Chain of Shoe Stores: A Statistical Analysis*, Chicago, University of Chicago Press, 1942, 54 pp.

(As editor, with E. M. Hoover) *Readings in the Social Control of Industry*, Series of republished articles on economics, Vol. 1, Philadelphia, Blakiston, 1942, 494 pp.

"Department-Store Cost Functions," in Lange, McIntyre, and Yntema, Editors, *Studies in Mathematical Economics and Econometrics, In Memory of Henry Schultz*, Chicago, The University of Chicago Press, 1942, pp. 222-254.

#### BAREND DE VRIES

Barend de Vries (Candidate Mathematics and Physics, Utrecht, Holland), graduate student in economics, assisted Koopmans and other staff members on part-time basis, in supervising and improving computational work based on new statistical methods. His work started August 1, 1946.

#### MEYER A. GIRSHICK

Meyer A. Girshick (M.A., Columbia, 1934, Ph.D., 1946) became a research consultant from January 1, 1946.

Girshick was research assistant to Professor Harold Hotelling at Columbia University. In 1937 he entered the service of the United States Department of Agriculture, where he was principal statistician in the Bureau of Agricultural Economics till October, 1946, when he joined the sampling staff at the Bureau of the Census. In 1944-1945 he participated in the development of sequential sampling analysis at the Statistical Research Group, Columbia University. He has published numerous articles on mathematical statistics.

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(With T. W. Anderson and H. Rubin) "Estimation of the Parameters of a Single Stochastic Difference Equation in a Complete System," presented at Washington, April 12, 1946, before a joint regional meeting of the Institute of Mathematical Statistics and the American Statistical Association.

(With D. Blackwell) "On the Functions of Sequences of Independent Chance Vectors with Applications to the Random Walk in  $k$  Dimensions," presented at Washington, April 12, 1946, before a joint regional meeting of the Institute of Mathematical Statistics and the American Statistical Association.

#### SOPHIA GOGEK

Sophia Gogek, fellow and graduate student in the department of economics, assisted Klein by collecting economic data on business fluctuations in the U.S.A., 1921-1941.

#### TRYGVE HAAVELMO

Trygve Haavelmo (Cand. Oecon., 1933, Ph.D., 1946, Oslo) became a research associate in 1943. He was in residence at Chicago as an instructor in the Department of Economics and a member of the agricultural economics research group from January, 1946, to March, 1947, when he returned to



Norway, continuing his connection with the Commission as a research consultant.

Haavelmo was a research assistant at the University Institute of Economics in Oslo, Norway, 1933-1938, and lecturer in statistical theory at the University of Aarhus, Denmark, 1938-1939. He studied at various European universities and in 1939-1942 at American universities on an American Scandinavian Foundation Fellowship and a Rockefeller Foundation Fellowship. In 1942-1944 he was statistician of the Norwegian Shipping and Trade Mission in New York, and in 1944-1945 he was commercial secretary of the Royal Norwegian Embassy in Washington. He has published various articles in economic journals in Norway, Denmark, and the United States. He is a Fellow of the Econometric Society.

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Cowles Commission Papers, New Series, Nos. 4 (1944), 12 (1945), 15 (1946).

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"The Statistical Implications of a System of Simultaneous Equations," *Econometrica*, Vol. 11, January, 1943, pp. 1-12.

"Statistical Testing of Business-Cycle Theories," *The Review of Economic Statistics*, Vol. 25, February, 1943, pp. 13-18.

"Strukturrelasjoner og Planøkonomi" (Structural Relations in a Planned Economy), *Statsøkonomisk Tidsskrift*, Oslo, 1946, pp. 71-83.

#### ALBERT G. HART

Albert G. Hart (B.A., Harvard, 1930; Ph.D., Chicago, 1936) served as a research consultant during the first half of 1946.

Hart was a member of the Department of Economics at the University of Chicago (as teaching assistant and instructor) from 1932 to 1939, and at Iowa State College (as associate professor and professor) from 1939 to 1945. He was director of research for the Debt Adjustment Committee of the Twentieth Century Fund, 1937-1938, and has done consulting work for the United States Treasury since 1943 (as resident consultant in Washington, 1943-1944). He was research economist for the Committee for Economic Development, 1944-1946, and visiting professor at Columbia University for the academic year, 1946-1947.

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(With M. G. de Chazeau, Gardiner C. Means, Howard B. Myers, Herbert Stein, and T. O. Yntema) *Jobs and Markets*, Committee for Economic Development Research Study, New York, McGraw-Hill, 1946, 143 pp.

"The Problem of 'Full Employment': Facts, Issues and Policies," *American Economic Review*, Vol. 36, Supplement, May, 1946, pp. 280-290.

"National Budgets and National Policy: A Rejoinder," *American Economic Review*, Vol. 36, September, 1946, pp. 632-636.

#### LEONID HURWICZ

Leonid Hurwicz (L.I.M., Warsaw, 1938) was a research associate from 1942 until June, 1946, when he became associate professor of economics at Iowa State College, continuing as a research consultant of the Commission.

Hurwicz has studied at the London School of Economics, the Post-

graduate Institute of International Studies at Geneva, the University of Chicago, and Harvard University, and has held a research and teaching fellowship at the Massachusetts Institute of Technology. In 1942 he assisted Professor Lange in his work on problems of business-cycle theory and time series, and Professors Dean and Yntema in problems of price determination. From 1942 to 1944 he was a member of the faculty of the Institute of Meteorology of the University of Chicago, engaged in teaching and research, and also taught a course in statistics in the Department of Economics. In 1945-1946 he held a fellowship of the John Simon Guggenheim Foundation.

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Cowles Commission Papers, New Series, Nos. 3 (1944), 13, 16, 17 (1946).

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"Aspects of the Theory of Economic Fluctuations," presented at Cleveland, September 13, 1944, before the Econometric Society (abstract in *Econometrica*, Vol. 13, January, 1945, p. 78).

"Sampling Aspects of Structural Estimation and Prediction," presented at Cleveland, January 25, 1946, before the American Statistical Association, the Econometric Society, and the Institute of Mathematical Statistics (abstract in *Econometrica*, Vol. 14, April, 1946, pp. 167-170, and reprinted in Cowles Commission papers, New Series, No. 17).

"Structural Estimation versus Regressions: Use for Policy and Prediction," presented at Washington, April 13, 1946, before joint regional meeting of the Institute of Mathematical Statistics and the American Statistical Association.

"Least Squares and Probability," presented at Chicago, August 21, 1946, before the Mathematical Club of the University of Chicago.

#### GEORGE KATONA

George Katona (Ph.D., Göttingen, 1921) joined the staff in January, 1943, as codirector of the study of price control and rationing and assumed the administrative direction of the project. On the completion of this at the end of 1944 he left to take a position in the Division of Program Survey, Bureau of Agricultural Economics, United States Department of Agriculture.

Katona was associate editor of *Der Deutsche Volkswirt* (The German Economist), Berlin, 1926-1933, as well as German correspondent of the *Wall Street Journal*, 1929-1933. He worked as an economic adviser in New York, 1934-1938. In 1938 and 1939 he did psychological research under grants-in-aid from the Carnegie Corporation of New York. As fellow of the John Simon Guggenheim Foundation from 1940 to 1942 he conducted investigations in war economics. He was connected with the New School for Social Research, New York, from 1935 as a research associate and later as a lecturer. He is the author of numerous articles in economic and psychological journals and of several books, including *War Without Inflation, The Psychological Approach to Problems of War Economy*, New York, 1942.

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Cowles Commission Monograph No. 9 (1945).

Cowles Commission Papers, New Series, Nos. 2, 7 (1944).

"Psychological Aspects of Business Decisions and Expectations." *American Economic Review*, Vol. 36, March, 1946, pp. 44-62.

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"Psychological Factors Contributing to Inflation," presented at Chicago, February 7, 1943, before the Seminar on the Changing Economy.

"Psychological Studies of Inflationary Attitudes and Expectations," presented at Chicago, March 11, 1943, before the Psychology Club of the University of Chicago.

"The Fight Against Inflation and Its Social Implications," presented at Chicago, August 7, 1943, before the 22nd Annual Institute of the Society for Social Research.

"The Impact of Price Control on Business," presented at Chicago, September 22, 1943, before the Seminar on the Changing Economy.

"Psychology and the Analysis of Business Behavior," presented at Chicago, May 16, 1944, as a public lecture of the Department of Economics and the School of Business of the University of Chicago.

"Report of Price Control and Rationing," presented at New York, May 6, 1944, before the annual meeting of the Conference on Price Research.

#### LAWRENCE R. KLEIN

Lawrence R. Klein (B.A., California, 1942; Ph.D., Massachusetts Institute of Technology, 1944) became a research associate in November, 1944.

Klein was George May Fellow and Teaching Fellow at Massachusetts Institute of Technology, 1943-1944, where he taught economics and statistics. His doctoral thesis, to be published by Macmillan, was on *The Keynesian Revolution*. During 1945-1946 he held a postdoctoral fellowship from the Social Science Research Council for work on econometric business-cycle theories.

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Cowles Commission Papers, New Series, Nos. 14, 18 (1946).

"Remarks on the Theory of Aggregation," *Econometrica*, Vol. 14, October, 1946, pp. 303-312 (to be reprinted in Cowles Commission Papers, New Series, No. 19).

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*The Keynesian Revolution*. Thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at the Massachusetts Institute of Technology, 1944. MS about 200 pages.

"Economic Fluctuations in U.S.A., 1921-1941," 67 pages, mimeographed, 1945.

(With J. Marschak and Edward Teller) "Dispersal of Cities and Industries," *Bulletin of Atomic Scientists*, April, 1946.

"Review of E. J. Howenstine, *Post-war Markets: A Guide Based upon Official Information*," *Journal of Political Economy*, Vol. 54, October, 1946, pp. 456-457.

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"From the *Treatise* to the *General Theory*: A Study in Keynesian Economics," presented at Cleveland, September 15, 1944, before the Econometric Society (abstract in *Econometrica*, Vol. 13, January, 1945, pp. 84-85).

Memorandum on Relocation of Cities, prepared for the Conference on

Atomic Energy, The University of Chicago, September, 1945 (mimeographed).

"Equations of Housing," presented at Washington, D. C., November 15, 1945, before a meeting of representatives of government agencies convened by the Research Division of the National Housing Agency.

"Use of Statistical Models in Economic Policy," presented at Washington, November, 1945, before the Division of Tax Research of the Treasury Department.

"A Macroeconomic System, U.S.A., 1921-1941," presented at Cleveland, January 24, 1946, before the Econometric Society (abstract in *Econometrica*, Vol. 14, April, 1946, pp. 159-162).

"Keynesian Economics and the Possibility of Liberal Capitalist Reform," presented at Chicago, April, 1946, before the Political Economy Club, the University of Chicago.

"Forecasts of National Product," presented at New York, Nov. 16, 1946, before the Income and Wealth Conference of the National Bureau of Economic Research.

#### TJALLING C. KOOPMANS

Tjalling C. Koopmans (Ph.D., Leiden, 1936) became a research associate in July, 1944. He is associate professor of economics at the University of Chicago.

Koopmans taught statistics and economics at the Netherlands Economic University and served on the staff of the Netherlands Economic Institute, both at Rotterdam, from 1936 to 1938. From 1938 to 1940 he was engaged in business-cycle research at the League of Nations in Geneva, especially with reference to United Kingdom data. In 1940-1941 he was on the staff of the Local and State Government Section (Princeton Surveys) of the School of Public and International Affairs, Princeton University, and also taught statistics at New York University. In 1941-1942 he was economist with the Penn Mutual Life Insurance Company, Philadelphia, engaged in research on interest rates on long-term securities. In 1942-1944 he did statistical work in the Combined Shipping Adjustment Board at Washington. He is the author of two books, *Linear Regression Analysis of Economic Time Series*, Haarlem, 1937, and *Tanker Freight Rates and Tankship Building*, Haarlem, 1939, and of numerous articles in economic and statistical journals. He is a Fellow of the Econometric Society.

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Cowles Commission Papers, New Series, Nos. 11 (1945), 17 (1946).

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"Review of *The Variate Difference Method*, by Gerhard Tintner," *The Review of Economic Statistics*, Vol. 26, May, 1944, pp. 105-107.

"Review of *Economic Fluctuations in the United States*, by Edwin Frickey," *The American Economic Review*, Vol. 34, June, 1944, pp. 377-381.

"Review of *Mathematical Statistics*, by S. S. Wilks," *The Journal of Political Economy*, Vol. 52, September, 1944, pp. 277-279.

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"Statistical Estimation of Simultaneous Economic Relations," presented at Cleveland, September 13, 1944, before the Econometric Society (abstract in *Econometrica*, Vol. 13, January, 1945, pp. 80-81).

"New Developments in the Statistical Measurement of Economic Re-

lations," presented at Chicago, April 4, 1945, before the Statistical Techniques Group of the Chicago Chapter of the American Statistical Association.

"The Statistical Estimation of Simultaneous Equations," presented at Ames, Iowa, May 9, 1945, at the Statistical Laboratory of Iowa State College.

"Full-Employment Policies," presented at Ames, Iowa, May 10, 1945, before the Social Science Seminar of Iowa State College.

"The Prevention of Inflation in Durable-Consumers'-Goods Markets during Reconversion," presented at Ames, Iowa, May 11, 1945, before the Department of Economics of Iowa State College.

"Memorandum on Relocation of Industry," prepared for the Conference on Atomic Energy, the University of Chicago, September, 1945 (mimeographed).

"Theory of Inventories under Perfect Competition," presented at Chicago, October 30, 1945, before the Political Economy Club of the University of Chicago.

(With Roy Bergh Leipnik) "Iterative Computation Methods in Estimating Simultaneous Relations," presented at Cleveland, January 25, 1946, before the American Statistical Association, the Institute of Mathematical Statistics, and the Econometric Society (abstract in *Econometrica*, Vol. 14, April, 1946, pp. 170-172, reprinted in Cowles Commission Papers, New Series, No. 17).

"Recent Developments in the Measurement of Simultaneous Economic Relations," presented at Washington, D.C., April 13, 1946, before the Washington Chapters of the American Statistical Association and the Institute of Mathematical Statistics.

"Statistical Inference in Dynamic Economic Models," presented at Ithaca, New York, August 23, 1946, before the Institute of Mathematical Statistics.

#### OSCAR LANGE

Oscar Lange (LL.D., Cracow, 1938) was a research associate of the Commission from September, 1939, until the autumn of 1945, when he was appointed Ambassador of Poland to the United States. He was on leave of absence as visiting professor at Columbia University during the academic year 1943-1944.

Lange has been lecturer in economics and statistics at the University of Cracow since 1931; lecturer in economics at the Polish Free University, Warsaw, since 1939; lecturer in economics at the University of Michigan, 1936, at the University of California, 1937-1938, and at Stanford University, 1938-1939; associate professor of economics, 1939-1943 and professor of economics since 1943, at the University of Chicago. He is a Fellow of the Econometric Society and the author of several books, including *The Statistical Study of Economic Fluctuations* (in Polish), 1931, and (with Fred M. Taylor) *On the Economic Theory of Socialism*, 1938, and numerous articles in economic journals.

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Cowles Commission Monograph, No. 8 (1944).

Cowles Commission Papers, New Series, Nos. 1, 8 (1944).

(As Editor, with Francis McIntyre and Theodore O. Yntema) *Studies in Mathematical Economics and Econometrics, In Memory of Henry Schultz*, Chicago, The University of Chicago Press, 1942, 292 pp.

"Say's Law: A Restatement and Criticism," in *ibid.*, pp. 49-68.

"Theoretical Derivation of Elasticities of Demand and Supply: The Direct Method," *Econometrica*, Vol. 10, July-October, 1942, pp. 193-214.

"The Foundations of Welfare Economics," *Econometrica*, Vol. 10, July-October, 1942, pp. 215-228.

"Special Interests Hammer at Price Control: War Savings, Rationing, Can Close 'Inflationary Gap,'" *New Leader*, Vol. 25, No. 24, June 13, 1942, p. 4.

"Taxation, Borrowing, not Wage Freezing, Can Close Inflation Gap," *New Leader*, Vol. 25, No. 25, June 20, 1942, p. 4.

"A Note on Innovations," *The Review of Economic Statistics*, Vol. 25, February, 1943, pp. 19-25.

"Review of Paul M. Sweezy, *The Theory of Capitalist Development: Principles of Marxian Economy*," *The Journal of Philosophy*, Vol. 40, July 8, 1943, pp. 378-384.

"The Theory of the Multiplier," *Econometrica*, Vol. 11, July-October, 1943, pp. 227-245.

*The Working Principles of the Soviet Economy*, Pamphlet Series No. 1 of the Russian Economic Institute, New York, 1943, 30 pp. (reprinted from *U.S.S.R. Economy and the War*, New York, 1943).

"Los Principios de la Economia Sovietica," *El Trimestre Economico*, Mexico, Vol. 11, July-September, 1944.

(With Abba P. Lerner) *The American Way of Business — The Role of Government in a System of Free Enterprise* (Problems in American Life, Unit No. 20), Washington, National Education Association, 1944, 93 pp.

"Marxian Economics in the Soviet Union," *American Economic Review*, Vol. 35, March, 1945, pp. 127-133.

"Economic Controls After the War," *Political Science Quarterly*, Vol. 60, March, 1945, pp. 1-13.

"The Inter-Relations of Shifts in Demand" (reply to notes by D. H. Robertson and J. R. Hicks), *Review of Economic Studies*, Vol. 12, 1944-45, pp. 75-78.

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"Planning in the Post-War World," presented at the University of Chicago, July 1, 1942, before Second Annual Conference for Teachers of the Social Sciences in Secondary Schools and Junior Colleges.

"Total War and Economic Trends," presented at Chicago, August 25, 1942, as a public lecture of the Social Science Division of the University of Chicago.

"Economic Nationalism versus World Organization," presented at New York, October 7, 1942, in conference at the Rand School of Social Sciences.

"Economic Planning, the Market, and Freedom," presented at New York, October 27, 1942, in conference at Institute of World Economics.

"Price Flexibility and Employment," presented at Cambridge, Massachusetts, March 11, 1943, before graduate students of the Department of Economics, Harvard University.

"The Contribution of Social Insurance and Full Employment to Freedom from Want," presented at New York, May 8, 1943, before the League for Industrial Democracy.

"The Soviet Union in the Postwar World," presented at Chicago, August 5, 1944, before the Society for Social Research.

"Monopoly and Employment," presented at the University of Toronto, November 20, 1944.

#### DICKSON H. LEAVENS

Dickson H. Leavens (B.A., Yale, 1909; M.A., 1915) has been a research associate since September, 1936, and has concurrently served as managing editor of *Econometrica*. He is a lecturer in economics at the University of Chicago.

Leavens has taught mathematics and other subjects at the College of Yale in China, Changsha, 1909-1928 and was treasurer, 1916-1928. From 1929 to 1933 he was on the research staff of the Harvard Graduate School of Business Administration. In 1934 he served in China and India as a special agent of the United States Treasury Department to investigate the silver situation. He has specialized in the study of the monetary use of silver and has published a number of articles on various phases of this subject, and a book, *Silver Money*, Cowles Commission Monograph No. 4, 1939.

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Cowles Commission Papers, New Series, No. 7 (1944).

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"Silver [Review of 1941]," *Engineering and Mining Journal*, Vol. 143, February, 1942, pp. 55-56.

(With John J. Croston) "Gold and Silver," chapter in *The Mineral Industry during 1941*, New York, McGraw-Hill, 1942, pp. 201-271.

"Silver [Review of 1943]," *Engineering and Mining Journal*, Vol. 144, February, 1943, pp. 79-80.

*Far Eastern Postwar Monetary Standards*, New York, The Monetary Standards Inquiry, 1943, 24 pp.

"Diversification of Investments," *Trusts and Estates*, Vol. 80, May, 1945, pp. 469-473.

"Diversification of Planning," *Trusts and Estates*, Vol. 81, September, 1945, pp. 206-209.

"Silver [Review of 1945]," *Engineering and Mining Journal*, Vol. 147, No. 2, February, 1946, pp. 74-76.

"Bullion Prices and the Gold-Silver Ratio, 1929-45," *Review of Economic Statistics*, Vol. 28, August, 1946, pp. 160-164.

#### ROY BERGH LEIPNIK

Roy Bergh Leipnik (B.A., Chicago, 1945, M.S., 1946) was full-time research assistant to Koopmans from February 1945 to July 1946. His work (not yet published) on mathematical statistics is indicated in this report, Section I.2, by the titles of items 5 and 9 and of Article II of Monograph No. 10.

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Cowles Commission Papers, New Series, No. 17 (1946).

#### H. GREGG LEWIS

H. Gregg Lewis (A.B., Chicago, 1936, Ph.D., 1947) became a research associate in September, 1939. From 1943 to 1945 he was on leave of absence as executive secretary and later assistant wage stabilization director of the Chicago Regional Office of the War Labor Board. In 1945 he served in the army, resuming his teaching at the University of Chicago in the autumn quarter and becoming a research consultant of the Commission.

Lewis was a university fellow in Economics at the University of Chicago, 1937-1938; fellow of the Brookings Institution, 1938-1939; instructor in economics, University of Chicago, 1939-1946, assistant professor, 1946-. He is the author of a number of papers on statistics and on the demand for steel.

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(With L. M. Court) "Production Cost Indices," *The Review of Economic Studies*, Vol. 10, Winter, 1942-43, pp. 28-42.

"Studies in the Elasticity of the Demand for Steel," thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at the University of Chicago, 1947.

#### JACOB MARSCHAK

Jacob Marschak (Ph.D., Heidelberg, 1922; M.A., Oxford, 1935) became research director in January, 1943. He is professor of economics at the University of Chicago.

Marschak was born in Kiev, Russia, and studied at the Institute of Technology at Kiev, 1915-1918, and at the Universities of Berlin and Heidelberg, 1919-22. He was assistant professor at the University of Heidelberg, 1930-1933; Chichele lecturer in economics at All Souls College, Oxford, 1933-1935; reader in statistics and director of the Institute of Statistics, University of Oxford, 1935-1939; professor of economics, Graduate Faculty of Social and Political Science, New York, 1939-1942. He is a fellow and member of the Council of the Econometric Society and served as its vice-president in 1944 and 1945 and as its president in 1946; he is a member of the advisory editorial board of *Econometrica*. He is the author of three books, *Die Lohn-diskussion*, 1930; *Die Elastizität der Nachfrage*, 1931; and (with W. Lederer) *Kapitalbildung*, 1936; and of numerous articles in economic journals. He is chairman of the executive committee of the Conference on Research on Income and Wealth, organized under the National Bureau of Economic Research; collaborating editor of the *Journal of the American Statistical Association*; and member of the Committee on Social Aspects of Atomic Energy, Social Science Research Council.

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Cowles Commission Papers, New Series, Nos. 5 (1944), 9 (1945), 13, 17 (1946).

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"Demand Elasticities Reviewed," *Econometrica*, Vol. 11, January, 1943, pp. 25-34.

"Money Illusion and Demand Analysis," *The Review of Economic Statistics*, Vol. 25, February, 1943, pp. 40-48.

"Income Inequality and Demand Studies: A Note," *Econometrica*. Vol. 11, April, 1943, pp. 163-166.



Editor (with Arthur Feiler) and author of Introduction (32 pp.) to *Management in Russian Industry and Agriculture*, by Gregory Bienstock, Solomon M. Schwartz, and Aaron Yugow, New York, Oxford University Press, 1944, 198 pp.

"The Economics of Atomic Power," *Bulletin of Atomic Scientists of Chicago*, Vol. 1, No. 5, February 15, 1946.

"Dispersal of Cities and Industries" (with L. R. Klein and E. Teller). *Bulletin of the Atomic Scientists*, Vol. 1, No. 9, April 15, 1946, pp. 12-15 and 20.

"Economic Aspects of Atomic Power," *Bulletin of the Atomic Scientists*, Vol. 2, Nos. 5-6, September, 1946, pp. 8-9 (paper presented at the Estes Park Conference on Atomic Energy, Estes Park, Colorado, June 25, 1946.)

Preface to Horst Mendershausen, *Changes in Income Distribution during the Great Depression*, (Studies in Income and Wealth, Vol. 7), New York, National Bureau of Economic Research, 1946, pp. xiii-xviii.

"Inflation," presented at Chicago, March 10, 1943, before the Seminar on the Changing Economy.

"Influence of Prices and Incomes on the Demand for Meat," presented at Chicago, March 24, 1943, before the Chicago Chapter of the American Statistical Association.

"Simultaneous Analysis of Demand and Supply," presented at Ames, May 5, 1943, before the Economics Seminar, Iowa State College.

"Studies on the Management of Russian Industry and Agriculture," presented at Ames, May, 1943, before the Social Science Seminar, Iowa State College.

"Simultaneous Random Equations in Statistical Economics," presented at Chicago, May 18, 1944, before the Mathematical Club of the University of Chicago.

"Random Production Functions," presented at Cleveland, September 13, 1944, before the Econometric Society (abstract in *Econometrica*, Vol. 13, January, 1945, pp. 81-82).

"Price Flexibility and Income Maintenance," presented at New York, May 5, 1944, before the annual meeting of the Conference on Price Research organized by the National Bureau of Economic Research.

"Current Tasks of the Cowles Commission," presented at Chicago, July 11, 1945, before the Committee on Instruction and Research of the Board of Trustees of the University of Chicago.

"Full Employment in the Postwar World" (with William W. Cooper and Philip M. Hauser), presented at Chicago, July 25, 1945, before the Conference of Teachers of the Social Sciences in Secondary Schools and Junior Colleges held at the University of Chicago.

"Theory of Games and Economic Behavior," presented at Chicago, August 3, 1945, before the Political Economy Club of the University of Chicago.

"The Prospects of Empirical Economics," presented at Washington, D.C., November 14, 1945, before the Seminar organized by the research staff of the Federal Reserve Board.

"Regressions and Structural Equations in Economics," presented at

Princeton, New Jersey, November 5, 1945, before the Graduate Seminar of the Department of Economics, Princeton University.

"Forecasts: Useful, Useless, and Faulty," presented at the Research Seminar of the Federal Reserve Bank of New York, New York City, on November 14, 1946.

"Atomic Energy and the Theory of Long-Run Effects of Inventions," presented at the Seminar of the Federal Reserve Board, Washington, D.C. on December 26, 1946.

#### KENNETH MAY

Kenneth May (A.B., California, 1936; M.A., 1937; Ph.D., 1946) became a research consultant of the Commission in September, 1946.

May was a Traveling Fellow of the Institute of Current World Affairs, 1937-1938, studying at the University of London (London School of Economics and University College) and University of Paris. He was a Teaching Fellow in Mathematics at the University of California, 1936-1937 and 1939-1940. He served in the 87th Mountain Infantry (10th Mountain Division) in the Aleutians (1943) and in Italy (1945). He was commissioned Second Lieutenant. He was instructor at Army University Study Center, Florence, Italy (1945). He is now assistant professor of mathematics at Carleton College.

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"The Aggregation Problem for a One-Industry Model," *Econometrica*, Vol. 14, October, 1946, pp. 285-298 (to be included in Cowles Commission Papers, New Series, No. 19).

"Technological Change as a Functional Variation," presented at Ames, Iowa, November 29, 1946, before the American Mathematical Society (abstract No. 74 in *Bulletin of the American Mathematical Society*, Vol. 53, January, 1947, p. 64).

"The Aggregate Effect of Technological Changes in a Two-Industry Model," presented by title at Swarthmore, Pennsylvania, December 29, 1946, before the American Mathematical Society (abstract No. 75 in *Bulletin of the American Mathematical Society*, Vol. 53, January, 1947, p. 64).

#### JACOB L. MOSAK

Jacob L. Mosak (A.B., Chicago, 1935, Ph.D., 1941) became a research associate in September, 1939. In 1941 he went on leave of absence, and held various positions in the Research Division of the Office of Price Administration, resigning from the Commission staff at the end of 1945.

Mosak was research assistant to Professor Henry Schultz at the University of Chicago, 1935-1938; Social Science Research Council Fellow, 1938-1939; instructor in economics, the University of Chicago, 1939-1944. He has published several articles in economic and statistical journals.

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Cowles Commission Monograph, No. 7 (1944).

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"On the Interpretation of the Fundamental Equation of Value Theory," in Lange, McIntyre, and Yntema, Editors, *Studies in Mathematical Economics and Econometrics, In Memory of Henry Schultz*, Chicago, The University of Chicago Press, 1942, pp. 69-74.

(With W. A. Salant) "Income, Money and Prices in Wartime," *American Economic Review*, Vol. 34, December, 1944, pp. 828-839.

"Forecasting Postwar Demand, III," *Econometrica*, Vol. 13, January, 1945, pp. 25-53.

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"Factors Affecting Adequacy of Demand for Potential Postwar Output," presented at Washington, November, 1945, before Conference on Research in Income and Wealth of the National Bureau of Economic Research.

#### GEORGE PERAZICH

George Perazich (B.S. in electrical engineering, California, 1933) joined the staff in March, 1947, as a research associate on the study of the economics of atomic energy.

Perazich was with the National Research Project, Philadelphia, as engineer in charge of studies in technology and industrial techniques, 1935-1940. For two years he was assistant director and consulting engineer, Research Advisory Service, Buffalo, New York. From 1944 to 1947 he served overseas with the United Nations Relief and Rehabilitation Administration, as director of industrial rehabilitation and deputy chief of supply. He is the senior author of *Industrial Research and Changing Technology*, *Industrial Instruments and Changing Technology*, and *Mechanization in the Cement Industry*, and author of several technical articles and special surveys.

#### DON PATINKIN

Don Patinkin (B.A., Chicago, 1943, A.M., 1945) joined the staff as a research assistant in May, 1946. He has been appointed research associate in the Cowles Commission and assistant professor of economics in the University of Chicago from July 1, 1947.

Patinkin held the Harper Fellowship in the University of Chicago in 1945-46, and holds a predoctoral fellowship of the Social Science Research Council in 1946-47.

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"Mercantilism and the Readmission of the Jews to England," *Jewish Social Studies*, Vol. 8, July, 1946, pp. 167-168.

#### HERMAN RUBIN

Herman Rubin (B.S., Chicago, 1944; M.S., 1945) joined the staff as a research assistant in July, 1944; he was absent in army service from March to December, 1945, returning to the staff in January, 1946. He became a research associate in November, 1946.

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Cowles Commission Papers, New Series, No. 10 (1945).

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"Asymptotic Distribution of Moments from a System of Linear Stochastic Difference Equations," presented at Ithaca, New York, August 22, 1946, before the American Mathematical Society and the Institute of Mathematical Statistics (abstract No. 332 in *Bulletin of the American Mathematical Society*, Vol. 52, September, 1946, pp. 827-828; abstract also in *Annals of Mathematical Statistics*, Vol. 17, December, 1946, p. 500).

(With Theodore W. Anderson, Jr.) "Estimation of Structural Coefficients through Linear Transformation of Regression Coefficients," presented at Ithaca, New York, August 23, 1946, before the Institute of Mathematical Statistics (abstract in *Annals of Mathematical Statistics*, Vol. 17, December, 1946, pp. 503-504.)

(With T. W. Anderson and M. A. Girshick) "Estimation of the Parameters of a Single Stochastic Difference Equation in a Complete System," presented at Washington, April 12, 1946, before joint regional meeting of the Institute of Mathematical Statistics and the American Statistical Association.

#### SAM H. SCHURR

Sam H. Schurr (B.A., Rutgers, 1938; M.A., 1939) joined the staff in the autumn of 1946 as codirector (with the rank of assistant professor) of the study of the economics of atomic energy.

Schurr was on the research staff of the National Bureau of Economic Research, 1939-1943; economist, Office of Strategic Services, 1943-1945; economic adviser to U.S. Representative, Allied Commission on Reparations, 1945-1946; and is now on leave from Division of German and Austrian Economic Affairs, U.S. Department of State. He is the author (with Harold Barger) of *The Mining Industries, 1899-1939: A Study of Output, Equipment and Productivity*, New York, National Bureau of Economic Research, 1944.

#### HERBERT A. SIMON

Herbert A. Simon (A.B., Chicago, 1936; Ph.D., 1943) became a research consultant of the Commission in April, 1947.

Simon was a research assistant at the University of Chicago, 1937-1938; staff member of the International City Managers' Association, and Assistant Editor of the *Municipal Year Book*, 1938-1939; director of administrative measurement studies at the Bureau of Public Administration, University of California, 1939-1942. Since 1942 he has been a member of the faculty of Illinois Institute of Technology where he is now professor of political science and chairman of the Department of Political and Social Science.

He is the author of *Fiscal Aspects of Metropolitan Consolidation*, 1943; and of *Administrative Behavior*, in press; and the coauthor of *Measuring Municipal Activities*, 1938; *Determining Work Loads for Professional Staff in a Public Welfare Agency*, 1941; *Fire Risks and Fire Losses*, 1943; and *Technique of Municipal Administration*, 1944. He has published a number of articles in the fields of municipal government, public administration, and economics.

#### JOHN H. SMITH

John H. Smith (B.A., Iowa State Teachers College, 1935; M.B.A., Chicago, 1939, Ph.D., 1941) was a research associate from September, 1940, to June, 1942, resigning to accept a position as statistical consultant in the office of the chief statistician, Bureau of Labor Statistics, United States Department of Labor.

Smith was a research and teaching assistant in the School of Business, the University of Chicago, 1936-1941, and instructor in statistics, 1941-

1942. He is the author of two books, *Tests of Significance and How to Use Them*, 1939, and *Statistical Deflation in the Analysis of Economic Series*, 1941.

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"Weighted Regressions in the Analysis of Economic Series," in Lange, McIntyre, and Yntema, Editors, *Studies in Mathematical Economics and Econometrics, In Memory of Henry Schultz*, Chicago, The University of Chicago Press, 1942, pp. 151-164.

#### SAMI TEKINER

Sami Tekiner, fellow of the Department of Economics, was full-time research assistant from July, 1944 to June, 1945. He participated in the studies on models for manufacturing industries and firms in the U.S.A.

#### THEODORE O. YNTEMA

Theodore O. Yntema (A.B., Hope, 1921; A.M., Illinois, 1922; C.P.A., Illinois, 1924; Ph.D., Chicago, 1929) became research director in September, 1939, and resigned in November, 1942, to become research director of the Committee for Economic Development, continuing on leave of absence as a research associate until the end of 1945.

Yntema has served on the faculty of the University of Chicago from 1923, becoming professor of statistics in the School of Business in 1930 and professor of business and economic policy in 1945. He was economic consultant to the National Recovery Administration, 1934-1935; head of economics and statistics in the division of industrial materials of the Defense Commission, 1940; consultant to the War Shipping Administration, 1942; consulting economist and statistician for the United States Steel Corporation and other companies at various times; and a director of the National Bureau of Economic Research, 1940-. He is a Fellow of the Econometric Society and of the American Statistical Association. He is the author of *A Mathematical Reformulation of the General Theory of International Trade*, and of a number of articles in economic journals; he directed most of the research leading to Vol. 1 of *TNEC Studies*, published by the United States Steel Corporation. He has also directed the research program of the Committee for Economic Development in which ten research reports (books) on current economic problems and three supplementary papers have been published and in which approximately fifteen additional reports are in process.

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(As Editor, with Oscar Lange and Francis McIntyre) *Studies in Mathematical Economics and Econometrics, In Memory of Henry Schultz*, Chicago, The University of Chicago Press, 1942, 292 pp.

"Henry Schultz: His Contributions to Economics and Statistics," in *ibid.*, pp. 11-17.

"Price Controls," in Chester W. Wright, Editor, *Economic Problems of War and Its Aftermath*, Chicago, the University of Chicago Press, 1942, pp. 112-125.

"Full Employment in a Private Enterprise System," *American Economic Review*, Supplement, March, 1944, pp. 107-117.

(With others) *Jobs and Markets*, Committee for Economic Development Research Study, New York, McGraw-Hill, 1946, 143 pp.

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No. 7. **GENERAL-EQUILIBRIUM THEORY IN INTERNATIONAL TRADE**, by JACOB L. MOSAK. 1944. 187 pages. Price \$2.50. This study applies the modern theory of economic equilibrium (as expounded by J. R. Hicks and others) to an important field.

No. 8. **PRICE FLEXIBILITY AND EMPLOYMENT**, by OSCAR LANGE. 1944. 114 pages. Price \$2.00. The author aims at the clarification of important concepts that have had much currency in the practical discussion of depressions and wars but remained too vague to allow of useful treatment.

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