COWLES COMMISSION
FOR RESEARCH IN ECONOMICS

REPORT FOR 1945

THE UNIVERSITY OF CHICAGO

REPORT FOR 1945

The last year of the war revealed vast practical achievements of physical science—all resulting from basic thoughts and measurements accumulated in previous decades. Physicists have also discovered, as have other people, that those achievements may lead to more harm than good if human affairs are not conducted with more insight and wisdom. Not only do we lack character and are uncertain of our goals. We are also ignorant of the means: we know too little of how men would behave in response to any given change of conditions or policies. It is a commonplace today that the lag between physical and social sciences is a dangerous one.

One field in which the efforts to lessen this lag offer a fair chance of success is the quantitative and causal analysis of economic processes and policies. The practical importance of economic policy is obvious: already at the present level of technology decent standards of living could probably be assured to this nation and to a considerable part of mankind if the economic problems of industrial unemployment and of agricultural depressions were solved. It is not claimed that all ills are economic, or that economic ills can be solved in the very near future by quantitative analysis of their causes. Intelligent understanding and measurement of some causes may merely help to remove some of the diseases. If it does, the leverage between efforts and results will be quite considerable.

RESEARCH ACTIVITIES

The research work of the Cowles Commission in 1945 can be described under three headings: I. Studies of economic fluctuations; II. Adaptation of statistical tools to economic analysis; III. Other research work. Items I and II continue the inquiries described in the *Report for 1944* as "Quantitative Studies of Economic Behavior."

I. STUDIES OF ECONOMIC FLUCTUATIONS

The study of economic fluctuations aims at explaining why, at any moment of the past, economic variables took the observed values. If the relevant causal relations are approximately known it becomes possible to say what will be the effect on the important variables of a given change in those relations. It should

become possible, for example, to estimate the effect of a given technical invention or of a proposed change in public policy.

The economic system can be presented in a simplified model as a set of simultaneous relations between variable quantities. Each relation either expresses the average behavior of a social group in a market (behavior equations); or it states some technological fact (production equations); or it defines certain variables (accounting identities). Here are a few examples of possible behavior relations, to be submitted to statistical tests and estimations:

Investment equation: Does businessmen's demand for plant and equipment depend on current and past profits? or, alternatively, on current and past sales, capital-goods prices, and existing capacity?

Inventory equation: Does businessmen's demand for inventories depend on current sales, current prices, rate of change of prices?

Consumption equation: Does consumer's demand depend on current (and, probably past) income and its distribution, on prices, on liquid assets, on capital gains?

Cash-demand equation: Does demand for cash (as distinct from securities or goods) depend on income, on interest rate?

Should a system of relations approximately describe the actual behavior, one would be able to give approximate answers to questions like this: What effect on national income can be expected from given monetary, fiscal, price, or wage policies? What policies can promise to stabilize the fluctuations of economic activity?

Students of business fluctuations will recognize the affinity between the studies outlined and the past work of Jan Tinbergen (Rotterdam School of Economics).[1] The main differences are due to the progress achieved in the data, the statement of the hypotheses, and the statistical tools.

More reliable data for a longer period of time are now available; but many questions will remain unanswered until, in addition to annual or monthly time series of national aggregates, frequent and detailed "cross-section" sample surveys of households and firms become available.

Priority is given to hypotheses that are compatible, apart from random deviations, with rational economic behavior — e.g., with each firm trying to achieve highest profits. Only if such

---

[1] *Statistical Testing of Business-Cycle Theories. II. Business Cycles in the United States of America, 1919-1932.* Geneva, League of Nations, Economic Intelligence Service, 1939, 244 pp. Some other methods of approach were briefly reviewed by Marschak in Cowles Commission Papers, New Series, No. 9.

hypotheses fail in statistical tests, uniformly foolish behavior (again apart from random deviations) is admitted as a second line of statistical attack. In particular, Hurwicz has been trying to relate the rational theory of the firm and of the assets to the results and hypotheses of the theory of economic fluctuations. In a number of unpublished notes presented for staff discussions, he treated the relation of real and monetary sectors of the economy, the theory of investment, and the theory of inventories. The latter problem was also approached by Koopmans. The theory of production functions was discussed in notes by Klein, Hurwicz, Koopmans, Marschak, and Tekiner.

Regarding statistical tools, an advance upon previous studies consisted mainly in requiring that the unexplained part of each dependent variable, from year to year, should not only be small (as indicated by a high correlation coefficient) but also have the properties of a random series. More profound changes in statistical tools are in preparation and will be discussed in Section II. So far they have been applied in an experimental way only. Therefore the numerical results of the work described here are approximations only.

The degree of approximation depends also, of course, on the quality of the data. Close cooperation with data-collecting agencies is necessary to judge the meaning and reliability of the material. Errors are also introduced by the fact that, to economize limited research resources, the number of variables must be kept moderate: to this end, variables are grouped into aggregates. For example, incomes of single families are replaced by a national total, and prices of single consumers' goods are replaced by an index number. Better approximations can be reached gradually as the data improve and the experience in handling them grows. In the reported studies, it was possible to make only the most essential separations; in particular, housing was treated in relations separate from other consumers' goods. Next it is planned to detach similarly the agricultural products (see below: III. Other Research), the services of transportation and public utilities, and the products of manufacturing and mining. For the last-named sector of economy, calculations of Tekiner will prove useful.

Obviously every detail added increases the work involved. A theory of aggregation or of "best index numbers" is needed. Such a theory would help to aggregate economic variables so as to minimize the error incurred in using economic relations for

prediction purposes, while keeping the cost of research within reasonable limits. It is well to remember that the degree of precision need not be closer than what is required to decide whether to accept or reject a given policy.

An alternative approach to the problem of best index numbers was tried by Klein in an article on "Macroeconomics and the Theory of Rational Behavior." Following a general suggestion of Francis Dresch (University of California), he attempts to define index numbers so as to give meaning to expressions like the "marginal product of aggregate labor"; however, following the suggestions of Hurwicz and others, Klein found it necessary to reject the specific formulas recommended by Dresch.

Klein prepared a preliminary draft of a study, "Economic Fluctuations in the United States, 1921-1941." It was mimeographed and circulated to solicit criticisms and suggestions of other workers in the field. Conferences were held with technicians of various government agencies (Federal Reserve Board, National Housing Agency, Department of Commerce, Bureau of the Budget, Treasury Department, and others) who were asked and kindly consented to give their reactions to the data and hypotheses used. A thorough revision is now on its way. It is discussed in weekly staff meetings.

By studying the properties of the consumption-income relation and the income distribution, Haavelmo derived "Multiplier Effects of a Balanced Budget,"[2] that had been largely overlooked in previous literature.

II. Adaptation of Statistical Tools to Economic Analysis

The economist is asked to predict how a given change in the relations constituting the system — for example, a given change in policy or technology — will affect the relevant variables. However, to obtain the answers he cannot perform an experiment; he cannot try out the new conditions in a laboratory. He has to rely on nonexperimental observations made under the previously existing conditions; the observations often consist of short time series. The *Report for 1944* (pp. 3-6) mentions the methodological problems arising out of these peculiarities of economic research and the conference convened by the Cowles Commission to discuss the subject. The conference took place from January 28 through February 1, 1945. The proceed-

[2] Cowles Commission Papers, New Series, No. 12.

ings were thoroughly revised and enlarged during 1945 and will be published as a Cowles Commission Monograph under the title, *Statistical Inference in Dynamic Economic Models.*

The volume consists of an Introduction (by Marschak) and three parts:

1. Simultaneous equation systems,
2. Problems specific to time series,
3. Specification of economic hypotheses.

Part 1 deals with four subjects: (a) The identification problem, by Koopmans and Rubin, with comments by Abraham Wald (Columbia) and by Hurwicz; (b) Structural estimation and computation, by Koopmans, Rubin, and Leipnik; this section was considerably enlarged since the conference and was stimulated by discussions, later in the year, with Adrian Albert (Chicago) and John von Neumann (Institute for Advanced Study, Princeton) ; it also contains a contribution by Harold Hotelling (Columbia) ; (c) Predictive *vs.* structural estimation by Hurwicz, with comments by Koopmans; (d) Comments on incomplete systems by Abraham Wald.

In Part 2, Hurwicz discusses the biases in least-squares estimates from short time series;[3] and Rubin, the case of nonstationary random processes. Papers by Hurwicz, H. B. Mann (Ohio State University), and R. L. Anderson (North Carolina State College) deal with trends and seasonal fluctuations. Koopmans outlines a treatment of continuous random processes — an approach hoped to be more satisfactory than the usual assumption of finite time lags.

Part 3 contains a paper by Koopmans defining economic equation systems that are "complete" for statistical purposes; one by Hurwicz on "nonadditive disturbances"; and one by Marschak and Klein on hypotheses arising in economics.

A great variety of problems remain unsolved. Most of them will be specified in the volume itself. Further exchange of ideas will be necessary. For example, the hypotheses used by the Cowles Commission ascribe random fluctuations of observed economic values to "disturbances in relations," the random "shifts" of classical economic theory; other investigators, e.g., recently Gerhard Tintner (Iowa State College) and Olav Reiersöl (Uni-

[3] The conference paper of William G. Madow (Bureau of the Census) was published later: "Note on the Distribution of the Serial Correlation Coefficient," *Annals of Mathematical Statistics*, Vol. 16, September, 1945, pp. 308–310. Cowles Commission Papers, New Series, No. 10 (by Rubin) deals with a related subject.

versity of Norway), have assumed, instead, the presence of "disturbances in variables" only, in the nature of observational errors. Some kind of synthesis will have to be sought.

A nontechnical exposition of some of the problems touched upon in Part 1 of the volume is given by Koopmans in Cowles Commission Papers, New Series, No. 11. Much further research is needed before the recommended change in methods can be presented in a stabilized form suitable for elementary textbooks.

III. OTHER RESEARCH WORK

Conferences were held in November to explore the possibilities of organizing research on demand for agricultural products, a joint project of the Cowles Commission and the Agricultural Economics Research Group of the University of Chicago (T. W. Schultz, D. Gale Johnson, and William H. Nicholls). In addition to the full-time staff of the two groups, the following persons participated: James P. Cavin, Meyer Girschick, and Margaret Reid, all of the United States Department of Agriculture; Richard Stone, author of *The Analysis of Market Demand* and Director of the Department of Applied Economics at the University of Cambridge; Chester M. Hardin, Political Science Department; and Trygve Haavelmo. The last-named will conduct the research under the joint responsibility of the two Chicago groups. The methods will be largely those mentioned in the previous two sections of the report. The results will help, it is hoped, in evaluating various agricultural policies. Mr. Haavelmo has been a research associate of the Cowles Commission since 1943. As will be remembered from previous reports he was one of the first writers to express doubts as to the applicability of traditional regression methods in studying economic relations.

Some attention was devoted to the new mathematical "theory of games and economic behavior," of von Neumann and Morgenstern. Discussions were held with the first of these authors. Extensive articles explaining the theory to readers of two economic journals were written by Hurwicz *(American Economic Review)* and Marschak *(Journal of Political Economy)*. This new approach to static economics promises to be fruitful if developed further, especially in application to monopolistic markets. It is, however, far from having reached the stage of empirical tests and measurement.

The social aspects of atomic energy attracted the attention of the Commission, partly in connection with the activities of the University of Chicago in this field. Two memoranda on relocation of cities and industries (by Klein and Koopmans) were presented at the conference organized by the University in September. A memorandum by Klein, Marschak, and Edward Teller (Institute of Nuclear Physics, The University of Chicago) was prepared later.

Davis has continued work on the *Encyclopedia of Mathematical Functions*, the outline of which was given in the *Report for 1942*. Volume 2, devoted to *Arithmetical Functions*, is nearing completion; in addition to many new tables, it presents a description of the functions tabulated, an historical account of the origin of mathematical constants, and a detailed survey of methods for solving algebraic and transcendental equations. He has carried out a study of the relationship between Engel curves and utility maps, the results of which are incorporated in a master's thesis by Miss Meryl Reich. He has continued work on the manuscript of *Patterns of History*, giving special attention to the construction of a curve showing the growth of power from ancient to modern times. Under the stimulus of the recent developments in the field of atomic energy, he has undertaken a revision of his *Philosophy and Modern Science*, originally published in 1931. He has also prepared four encyclopedia articles during the year.

Koopmans is engaged in a study in which the principles of welfare economics and the concepts of production theory are applied to transportation, especially shipping. The methods and concepts developed in this study provide a foundation for a theory of industrial location from the point of view of welfare economics.

Leavens has continued to keep in touch with developments affecting silver and has prepared two articles for publication in 1946.

UNIVERSITY 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 Simeon E. Leland, chairman of the Department of Eco-

nomics. The vice-chairman is Louis Wirth, Secretary of the So-
cial Science Research Committee of the University.

GRANTS

COWLES COMMISSION SEMINARS

Seminars, open to faculty members, graduate students, and
others interested, were held during the year as listed below. The
seminars were held in the evening and were often preceded by
an afternoon talk by the speaker to the Cowles Commission staff
on a more technical level.

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 Bud-
get."

October 29. Jacob Viner, Professor of Economics, The University of
Chicago, "Discussion of Trygve Haavelmo's Monograph, 'The Probability
Approach in Econometrics'" (supplement to *Econometrica*, Vol. 12, July,
1944).

November 19. Donald M. Fort, The University of Chicago, "A Modi-
fied Keynesian Theory."

November 26. Richard Stone, Director, Department of Applied Eco-
nomics, University of Cambridge, "National Income and Social Accounting."

December 10. W. Edwards Deming, Bureau of the Budget, Washing-
ton, D.C., "On Some Criteria of Sampling, with an Illustration in Popula-
tion Sampling."

December 17. George Katona, Division of Program Surveys, Bureau
of Agricultural Economics, U.S. Department of Agriculture, "Wartime Sav-
ings and Their Effects."

STATISTICAL TEACHING IN THE DEPARTMENT
OF ECONOMICS

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 between mathematics, economics, and statistics.

SARAH FRANCES HUTCHINSON COWLES FELLOWSHIPS

Two graduate Fellowships for women will be awarded by the University of Chicago for the academic year 1946-47 upon nomination by the Cowles Commission. Applicants must be students of outstanding promise, preparing for the degree of Master of Arts or Doctor in the fields of Social Sciences and Statistics. Preference will be given to students who will be working on quantitative economics or mathematical statistics in the Departments of Economics or Mathematics or in the School of Business.

The Fellowships amount to $1000 each. The Cowles Commission will consider a supplementary contribution for the whole or a part of the Fellowship period at a rate of $500 per year if the work of the Fellowship holder lies within the Commission's field of interest.

OFFICES AND LIBRARY

With increased staff the office space allotted to the Cowles Commission when it moved to Chicago in 1939 has become inadequate. The officers of the Social Science Division have met this situation by giving the Commission, in exchange for a small room, a large one which has been divided into five individual offices with space in the center for additional desks and for conferences.

Additions to the library during the year totalled 144 books, 476 pamphlets, and 16 bound volumes of journals. Some 90 periodicals are received currently. The total collection, including the library of the late Professor Henry Schultz, the property of the University but shelved in the Commission's offices, contains about 3000 books and bound periodicals, and over 4000 reprints and pamphlets.

STAFF NEWS

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 its weekly staff meetings, by correspondence, or by other occasional contributions.

Marianne Abeles, fellow of the Department of Economics and candidate for the Ph. D. degree, has been appointed a part-time research assistant beginning in 1946.

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.

STATISTICS I: UNIVARIATE ANALYSIS. Statistical theory of one variable. Fundamental laws of probability. Probability and frequency distributions. Sampling distributions and tests of significance. Sampling of human populations. Principles of estimation. Theory of testing a hypothesis.

STATISTICS II: MULTIVARIATE ANALYSIS. Joint probability distribution. Correlation and regression in two and more variables. Analysis of variance. Tests of significance in multivariate analysis. Problems arising if the data are time series.

APPLICATIONS OF STATISTICS TO ECONOMICS. 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.

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 American economy.

INTRODUCTION TO MATHEMATICS FOR ECONOMISTS. A survey of those parts of mathematical analysis which are used in economics. Fundamental mathematical concepts: functions, 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.

The courses on statistics and mathematics are additional to the relevant courses given in the Department of Mathematics and the School of Business. Statistical courses are also given in the Departments of Education, Psychology, Sociology, and Zoology.

Staff members of the Cowles Commission are also scheduled to give the following courses: The Divisional Course in Economics; Imperfect Competition; Case Studies in Welfare Economics; and The Theory of Income and Employment.

Theodore W. Anderson, Jr., joined the staff as a research associate in November, 1945. Mr. Anderson received the degree of B.S. at Northwestern University in 1939, and the degrees of M.A. and Ph. D. at Princeton University in 1942 and 1945 respectively. He was an instructor at Princeton University, 1941-43, and a research mathematician in the Statistical Research Group there, 1943-45. He is the author of several papers on mathematical statistics.

Harold T. Davis, in addition to his duties as chairman of the Department of Mathematics at Northwestern University, undertook the work of Professor Oliver Lee in the Department of Astronomy during the latter's absence in the winter quarter.

Joel Dean became a permanent member of the faculty of Columbia University as professor of business economics in the School of Business.

Meyer A. Girshick was appointed research consultant as from January 1, 1946. This formalizes the present close cooperation on new statistical methods and on their application to the analysis of food demand. Girshick has an M.A. of Columbia University (1934) and has completed the requirements for Ph.D. in mathematical statistics. He was research assistant to Harold Hotelling until 1937, and has been employed since by the United States Department of Agriculture; he is at present Principal Statistician at the Bureau of Agricultural Economics. In 1944-45 he participated in the development of sequential sampling analysis at the Statistical Research Group, Columbia University. He has published numerous articles on mathematical statistics.

Sophia Gogek, fellow of the Department of Economics and candidate for the Ph. D. degree, was a part-time research assistant for several months during 1945.

Trygve Haavelmo moved to Chicago at the beginning of 1946 to start the study of demand for food described in Section II of this report.

Albert G. Hart became a research consultant at the end of 1945. This merely formalizes his participation and interest in the work of the Cowles Commission. Hart received his A.B. degree at Harvard (1930). He has the degree of Ph.D. of the University of Chicago (1936), where he taught during 1932-1933 as teaching assistant and later as instructor. He was on the faculty of Iowa State College, Ames, as an associate professor (1939-1942). He has done research work for the U. S. Treasury as a

consulting expert since 1943. Hart was director of research of the Debt Adjustment Committee of the Twentieth Century Fund in 1937-1938. He is currently a research economist of the Committee for Economic Development.

Leonid Hurwicz was granted a fellowship by the John Simon Guggenheim Foundation for the year beginning June 1, 1945 for a study of the basic concepts of the theory of economic fluctuations. Mr. Hurwicz has been appointed associate professor of economics at Iowa State College, but is on leave of absence during the period of the fellowship.

Lawrence R. Klein was granted a postdoctoral fellowship by the Social Science Research Council for the year beginning October 1, 1945, for work on econometric business-cycle theories.

Oscar Lange continued his work on economic controls and monetary policies. He also worked on the mathematical foundations of macroeconomics. In the late summer he was appointed Ambassador of Poland to the United States and is on leave of absence from the University of Chicago.

Roy B. Leipnik, candidate for the degree of S.M. in mathematics, has been a full-time research assistant since February 1, 1945.

H. Gregg Lewis, research consultant, was discharged from army service, and resumed his duties as instructor in economics at the University of Chicago in the autumn quarter of 1945.

Jacob Marschak continued to serve on the executive committee of the Conference on Research in Income and Wealth, organized under the National Bureau of Economic Research. He was also chairman of the committee responsible for editing the volume, *National Incomes of Various Countries*, to be published under the auspices of the Conference.

Jacob L. Mosak continued as Chief of the Economic Analysis and Forecasting Branch of the Research Division of the Office of Price Administration in Washington.

Herman Rubin was in the army beginning March, 1945. He was discharged at the end of the year and resumed his duties as part-time research assistant at the beginning of 1946.

Sami Tekiner completed in July, 1945, his term of appointment as a research assistant of the Cowles Commission and Fellow of the Department of Economics.

Theodore O. Yntema has continued as research director of the Committee for Economic Development.

THE ECONOMETRIC SOCIETY IN 1945

The Cowles Commission offices have continued as the headquarters of the Econometric Society, an international society for the advancement of economic theory in its relation to statistics and mathematics, founded in 1930. Several members of the Commission staff hold offices in the Society. Jacob Marschak was vice-president of the Society in 1944 and 1945 and has been elected president for 1946; he is also a member of the advisory editorial board of its quarterly journal, *Econometrica*. Alfred Cowles is secretary and treasurer of the Society and business manager of *Econometrica*. Oscar Lange was acting editor of *Econometrica*, 1943-1945, when it was impossible to communicate with the editor, Professor Ragnar Frisch of the University of Norway, and continues as a member of the advisory editorial board. Dickson H. Leavens is managing editor and Harold T. Davis is an associate editor.

During 1945 Volume 13 of *Econometrica* was published, consisting of four quarterly issues totalling 368 pages. The regular mailing list includes 309 subscribers, chiefly libraries, and 728 members of the Society, of whom 185 subscribers and 374 members are in the United States and the remainder in 48 foreign countries. During the war it was impossible to mail copies to enemy and occupied countries, so many of the foreign members were inactive, but during 1945 contact was resumed with a large number of them.

No meetings of the Society were held during 1945 on account of the transportation situation, but plans were made for a meeting in Cleveland, Ohio, January 24-27, 1946.

COWLES COMMISSION PUBLICATIONS
1945

MONOGRAPHS

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

CONTENTS

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. Keep-

ing 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.

COWLES COMMISSION PAPERS, NEW SERIES

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.

OTHER PUBLICATIONS AND PAPERS

In addition to the 1 monograph and the 4 Cowles Commission Papers, members of the staff have published 11 articles and presented 23 papers before meetings of scientific societies, as follows:

ALFRED COWLES

"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.

HAROLD T. DAVIS

"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 Compu-*

tation, Vol. 1, April, 1945, pp. 399-400.

"Review of H. W. Holtappel, *Tafels von e^x*, Groningen, Nordhoff, 1938," *Mathematical Tables and Other Aids to Computation*, Vol. 1, October, 1945, pp. 437-438.

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

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

LEONID HURWICZ

"Least Squares and Probability," presented at Chicago, August 21, 1945, before the Mathematical Club of the University of Chicago.

"The Theory of Economic Behavior," *American Economic Review*, Vol. 35, December, 1945, pp. 909-925 (will be reprinted as Cowles Commission Papers, New Series, No. 13A).

LAWRENCE R. KLEIN

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

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.

TJALLING KOOPMANS

"New Developments in the Statistical Measurement of Economic Relations," 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.

OSCAR LANGE

"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.

DICKSON H. LEAVENS

"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.

JACOB MARSCHAK

"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.

JACOB L. MOSAK

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

"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.

COWLES COMMISSION MONOGRAPHS

No. 1. DYNAMIC ECONOMICS, by CHARLES F. ROOS. 1934. 275 pages. Price $3.50. Mathematical analysis is here applied in the investigation of economic theory, especially by differentiating between theories of static and dynamic economics.

No. 2. NRA ECONOMIC PLANNING, by CHARLES F. ROOS. 1937. 596 pages. Price $5.00. This book describes the policies and working of the NRA and discusses the problem of economic planning.

No. 3. COMMON-STOCK INDEXES, by ALFRED COWLES and ASSOCIATES. Second Edition, 1939. 499 pages. Price $6.00. New monthly indexes of (1) stock prices, (2) stock prices adjusted for reinvestment of cash dividends, and (3) yield expectations; and annual indexes of (4) yields, (5) dividend payments, (6) earnings-price ratios, and (7) earnings; all for 69 industry groups or combinations of groups, 1871-1938.

No. 4. SILVER MONEY, by DICKSON H. LEAVENS. 1939. 439 pages. Price $4.00. A sketch of the history of the monetary use of silver, followed by more detailed consideration of recent developments.

No. 5. THE VARIATE DIFFERENCE METHOD, by GERHARD TINTNER. 1940. 175 pages. Price $2.50. A full account of the history and use of this method for the analysis of time series. Certain new devices of treatment are presented, and extensive tables are given to aid calculations.

No. 6. THE ANALYSIS OF ECONOMIC TIME SERIES, by HAROLD T. DAVIS. 1941. 620 pages. Price $5.00. This book reviews the historical development of the subject, describes the methods used, and makes applications to a variety of economic phenomena.

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.

No. 9. PRICE CONTROL AND BUSINESS, by GEORGE KATONA. 1945. 246 pages. Price $3.00. A study of the working of price control based on field studies among producers and distributors of consumers' goods in the Chicago area, 1942-44.

In addition, the Cowles Commission has sponsored the publication of a text book by two members of its staff:

ELEMENTS OF STATISTICS, by HAROLD T. DAVIS and W. F. C. NELSON. Second edition, 1937. 434 pages. Price $4.00. The elements of the subjects are presented without recourse to calculus, but with as complete mathematical treatment as is thus possible.

Orders should be sent to
THE PRINCIPIA PRESS, INC.
BLOOMINGTON, INDIANA