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**Staff Reports
on Research
Under Way**

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1. ECONOMIC AND SOCIAL PERFORMANCE

Productivity, Employment, and Price Levels

Introduction

Inflation, or more broadly, the behavior of prices, and the problems of economic measurement and economic policy associated with it, are again emphasized in this year's program, along with the closely related topic of productivity change. Two new studies begun during the year, Inflation, 1964–1974, by Joel Popkin and Avram Kisselgoff, and Research and Development and Firm Productivity, by M. Ishaq Nadiri, are described below.

Among continuing projects, Robert J. Gordon reports on studies of The Measurement of Durable Goods Prices and Labor Markets and Inflation. The volume which is the final report on the former study, is being revised by the author after staff review. Phillip Cagan's study of The Short-run Behavior of Prices and Nadiri's on The Behavior of Output and Input Prices are both close to completion, with some reports published or in press and others in the final stages of preparation. Solomon Fabricant has resumed work on his volume on The Problem of Inflation, which is to be a nontechnical summary of knowledge in this field.

The program of research in Productivity, Employment, and Price Levels was begun under grants from the Sloan Foundation and the Alex C. Walker Educational and Charitable Foundation and has been supported in the past year or two mainly by several grants from the National Science Foundation.

<div style="text-align:right">Robert E. Lipsey</div>

Inflation, 1964–1974

This study, financed by the National Science Foundation and under way since November 1974, is intended to contribute to understanding the causes of the last decade's inflation and how it was transmitted through the economy.

In examining these causes, the interrelationship between macro policies and micro developments, such as the sharp rise in raw commodity prices, will receive considerable attention. To this end, work is under way to develop the necessary data base at the micro level. We began with the petroleum sector and have made preliminary estimates of prices and price indexes of crude oil input to U.S. refineries, of output at the refinery, and of prices paid by consumers and other final users. Similar series will be constructed for other major raw commodity groups.

Such series, together with those on price determinants, facilitate understanding of price behavior in each sector and provide a basis for establishing links between prices in specific sectors and the overall price level. The development of the linkage mechanism is another major aspect of the study. This mechanism is a refinement of earlier modeling of price behavior by stage of process. Working with the 484 order input-output table for 1967, manufacturing industries have been defined as primary, intermediate, and finished goods producers. Finished goods industries have been grouped into categories such as consumer home goods, consumer foods, beverages and tobacco, and machinery and equipment.

There is no unique way to so classify manu-

facturing industries because interindustry relationships are complex. There are two primary strategies underlying the classifications in this study. The first is to designate as finished goods industries those that account for the bulk of manufacturers' sales to final demand and to specify as primary producers those industries accountable for the bulk of purchases from the mining and agricultural sectors; all other industries are designated as intermediate. The second strategy is to alter the above designations where necessary to make them consistent with available groupings of monthly census data on shipments, inventories, new and unfilled orders, and FRB data on industrial production.

When supplemented by wage indexes, the result will be a comprehensive data base for the analysis of prices. It permits estimation of models of price determination among the various categories of manufacturing industries. The fact that these categories correspond with identifiable segments of the I-O input-output table will permit the model to be integrated with the typical macro models now in use—in this study the one developed at the Wharton School. When the integration is complete it will be possible to shock the model and trace the inflationary consequences. An effort is being made to determine the major "external" and "internal" shocks that have played an important part in the last decade's inflation.

<div align="right">

Avram Kisselgoff
Joel Popkin

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Research and Development and Firm Productivity

The purpose of this research is to discover the relationship between R & D activities and productivity at the level of the individual firm. The specific questions considered are:

1. How do R & D activities fit into the firm's optimal input decision process and what are the explicit determinants of these activities?

2. How does the demand for factors of production change in response to changes in the firm's R & D activities? In what way does the factor endowment of a firm affect its R & D intensity?

3. What are the dynamic adjustment proc-

esses underlying each input decision, including R & D investment, and how is the adjustment process of one input affected by the adjustment pattern of other inputs?

4. What are the short-run effects of changes in relative prices and demand on R & D activities and other inputs? How do these effects differ from the long-run impacts of prices and sales on factors including R & D activities?

To analyze these issues, we have constructed a dynamic model of firm behavior. The model is derived from a cost minimization principle and its dynamic feature is that it traces the interaction of the adjustment paths of R & D investment, capital stock, production workers, and scientific personnel. It is possible, in the context of this model, to study the "static" and "dynamic" influences of R & D on employment and investment behavior, and the impact of changes in these variables on R & D expenditures. The possibilities of complementarity or substitution among different types of capital and labor and R & D in the short and long runs are also examined. Furthermore, it is possible to estimate the total and partial productivity indices for each firm and to examine the transitory and long-run responses of these indices to changes in exogenous variables.

In estimating the model we have compiled the necessary data for 100 companies for the period 1953-1972. The appropriate variables have been assembled by merging data from various sources, including supplemental data on costs of R & D personnel, price of capital goods, and relative prices obtained from the U.S. Department of Commerce. Information on some alternative indices of innovative activities such as patents has also been assembled. With a prototype estimation of the model we have begun using the data for six companies.

George Bitros is associated with me in this project.

<div align="right">

M. Ishaq Nadiri

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The Measurement of Durable Goods Prices

I am now revising, after staff reading committee review, my monograph, "The Measurement of Durable Goods Prices," in which new price indexes are developed for almost 100 different

types of durable goods for the period 1947–1970 from information that is independent of the sources used for the official U.S. government price indexes for the same products. The new index declines by 10 percent between 1947 and 1970, whereas the official index for the same products using the same weights rises by 85 percent. During the past year the book has been extended in two directions.

An additional chapter on the behavior of automobile prices concludes that previous empirical work on automobile prices has substantially understated the upward bias in the official price indexes. The conclusions are summarized in Table II-1, with major results displayed for the period 1949–1970 and for the two subperiods 1949–1960 and 1960–1970. A hedonic regression price index for the list prices of new cars increased by 15.0 percent over the entire period (line 1), in comparison with a 29.9 percent increase in the CPI (line 2). The CPI rose considerably faster than the hedonic index in the first subperiod and more slowly thereafter.

Much of the chapter, however, is devoted to a detailed comparison of automobile models in 1949, 1960, and 1970, which are "closely similar" in size and weight; the analysis suggests that the hedonic index understates quality change relative to the "truth" (line 4) by substantially more than the CPI underestimates quality change relative to the hedonic index (line 3). The primary sources of quality change unmeasured by the hedonic technique are, first, a considerable improvement in fuel consumption between 1949 and 1960, and, second, substantial "weight-reducing" improvements in quality between 1960 and 1970. The final list price index, adjusted for quality change, declines by 14.7 percent between 1949 and 1970, in contrast to the 29.9 percent increase in the CPI.

But reliance on list prices is deceiving and ignores the elimination of premiums and the introduction of discounts as the postwar period proceeded. A hedonic index designed to proxy for transaction prices (based on used prices adjusted for depreciation) declines by 3.3 percent (line 6), in contrast to the 15.0 percent increase in the hedonic list price index. The extra quality adjustments apply to transactions prices as well, leading to a final quality-adjusted transactions price index that declines by 28.8 percent over the entire period. In contrast, the National Income Accounts' deflator for passenger cars as a component of producers' durable investment increases by 32.1 percent, a bit more than the CPI. Thus the overall bias in the NIA deflator is 60.9 percent, with a somewhat smaller bias in 1960–1970 than in 1949–1960.

The chapter is currently being extended to 1974, with preliminary results indicating that the bias has been eliminated in the 1970s, since (1) manufacturers are now submitting quite complete reports on the value of quality changes, (2) the spread of discounting has narrowed dealer new-car margins sufficiently to prevent any appreciable further decline in transaction

TABLE II-1

Final Adjustment of Hedonic Indexes
for Unmeasured Changes in Quality
(changes in percent)

	1949–1960	1960–1970	1949–1970
1. Change in hedonic list price index	4.3	10.2	15.0
2. Change in CPI	26.2	2.9	29.9
3. Estimated quality change measured by hedonic but not CPI	21.9	−7.3	14.9
4. Estimated change in quality not measured by hedonic index	13.7	14.1	29.7
5. Estimated "true" change in list price	−9.4	−3.9	−14.7
6. Change in hedonic "transaction price proxy"	0.5	−3.9	−3.3
7. Change in final quality-adjusted "transaction price proxy"	−13.2	−18.0	−28.8
8. Change in NIA deflator	25.7	5.1	32.1
9. Upward bias in NIA deflator	38.9	23.1	60.9

SOURCE: Robert J. Gordon, *The Measurement of Durable Goods Prices,* National Bureau of Economic Research, forthcoming, Table 7-6.

relative to list prices, and (3) fuel economy deteriorated between 1970 and 1974.

The second extension of the results reported last year has involved the collection of semi-annual data for 1969–1974 not only to update the book, but also to evaluate the period of price controls between 1971 and 1974. Were price controls evaded either by a reduction in quality or an increase in the ratio of transaction prices relative to list prices, as compared to what would have happened in the absence of controls? A preliminary look at the evidence suggests a negative answer to both parts of this question; a thorough evaluation will be included in the final version of the book.

<div align="right">Robert J. Gordon</div>

Labor Markets and Inflation

The theme of this research project is an attempt to improve the theoretical foundations of unemployment and inflation theory and to subject the major hypotheses to empirical testing. During the past year research has been conducted in two main areas: (1) the welfare cost of changes in "structural" unemployment, and (2) the interrelations between domestic and international theories of inflation.

(1) My earlier paper, "The Welfare Cost of Higher Unemployment," summarized in last year's *Annual Report,* analyzed the effects on output and welfare of an increase in the average unemployment rate caused by a reduction in aggregate demand. As a sequel I presented "On Assessing the Significance of a Structural Shift in Unemployment," at a recent conference at the University of Rochester. A structural shift in unemployment is defined as a change in the average unemployment rate attributable to some combination of (a) a change in the unemployment rates of subgroups in the labor force relative to a benchmark subgroup (e.g., prime-age adult males), and/or (b) an alteration in the relative shares of the various subgroups.

If the primary purpose of an aggregate unemployment concept is to measure the extra output that could be produced by unutilized labor, those who concentrate only on the unemployment rate of prime-age adult males implicitly assume that only they have the capacity to produce output, since no weight in the measurement is given to unemployment among women and teenagers. In contrast to this attitude, some writers would consider as exactly equivalent an increase in aggregate unemployment concentrated among adult males and an increase concentrated among women and teenagers, implicitly assuming that unemployed workers of all demographic groups have the same capacity to produce extra output.

The choice between these two views depends largely on an accurate measurement of the productivity of women and teenagers relative to men. If female and teenage productivity were identical to that of men, their lower average earnings would reflect pure Becker-style discrimination, and an unemployed woman or teenager would represent as much unutilized capacity as an unemployed man. On the other hand, lower female and teenage earnings might reflect the rational decision of employers not to invest heavily in specific human capital acquisition for workers whose expected job tenure is short. Two types of evidence are examined that bear on these different interpretations of lower female and teenage earnings. First, cross-sectional studies, both of specific occupations and of large heterogeneous employee groups, appear to explain a substantial portion of the male-female wage differential as caused by the lesser on-the-job experience of women. Second, a time series analysis of the relative earnings of different demographic groups indicates a steady widening in the male-female earnings gap for those age groups (35-64) whose accumulated on-the-job experience is most important. The age-earnings profile of men is now even steeper relative to that of women than was true twenty years ago, supporting the hypothesis that the lower earnings of women reflect true productivity differences associated with lower amounts of specific human capital. Unfortunately the data cannot be used to determine whether the exclusion of women from high-payoff job ladders has been attributable to a rational choice reflecting shorter expected job tenure, or to outright discrimination that without ostensible cause forced women into occupations in which experience earns a low reward.

(2) "Interrelations Between Domestic and In-

ternational Theories of Inflation" consists, first, of a theoretical analysis of the "domestic" or "Phillips curve" approach represented by the wage and price equations in most large econometric models for both closed and open economies, and, second, of a parallel analysis, based on the monetary theory of the balance of payments, of the determinants of price change in an open economy with separate traded and nontraded goods sectors. The aim is to reconcile the domestic approach, which implies that the domestic price level can diverge permanently from the world price level in a fixed-exchange-rate regime, with the international monetary approach, which is based on contrary assumption.

The analysis suggests that the logical consequences of the domestic theory are incompatible with those of the international monetary approach only as the consequence of a partial equilibrium analysis that ignores the effects of higher imported inflation on the domestic commodity and money markets. When full interaction with other markets is taken into account, there can be no permanent divergence between domestic and world inflation in a fixed-rate regime; a one-shot devaluation accelerates the domestic rate of inflation until the domestic price level converges with the higher prices of traded goods expressed in domestic currency; and only a continuous currency appreciation allows a permanent reduction of domestic inflation below the world rate.

The second part of the paper extends the analysis of the monetary theory of the balance of payments. This theory heretofore has assumed perfectly flexible prices, in which case a nation running a balance of payments deficit under fixed-exchange rates has only itself to blame—extra reserves can be attracted simply by reducing the creation of domestic credit below the increase in the demand for money, and the assumption of flexible prices prevents restrictive monetary policy from creating a recession. But in my more realistic alternative version, disequilibria in the domestic labor and commodity markets are not instantaneously eliminated. In the nontraded goods sector the adjustment of the wage rate is assumed to eliminate only a portion of a labor market disequilibrium in any given time period. If the non-

traded goods price level is assumed to be "marked up" over the wage rate, the level of nontraded goods output becomes a residual, the level of which is determined by domestic monetary policy, in contrast to the standard version of the monetary theory, in which the nontraded goods market is assumed to clear, leaving the nontraded goods price as a residual determined by domestic monetary policy. It is demonstrated that the impact effect of a devaluation can be either an increase or a decrease in the domestic wage rate, depending on the relative size of the income elasticity and the relative price elasticity of the demand for nontraded goods. The policy conclusion is that policymakers in open economies cannot blindly follow the path of reducing the growth rate of domestic credit; they face the same short-run inflation-unemployment tradeoff as in a closed economy, even if in the long run their inflation rate is completely imported from abroad.

Robert J. Gordon

The Short-Run Behavior of Prices

Two papers containing the results of my study of inflationary price behavior are being published during 1975 in *Explorations in Economic Research*. The first is "Changes in the Recession Behavior of Wholesale Prices in the 1920s and World War II" in the winter 1975 issue, Vol. 2, No. 1; and the second is "Inflation and Market Structure in 1967–1973," in the spring 1975 issue, Vol. 2, No. 2. A third paper, now ready for circulation, will complete the study.

The third paper, "Step Cycles in the Rate of Change of Prices, Wages, and Output in Two-Digit Industries Since 1954," examines fourteen industries during four business cycles from 1954 to 1972. The paper is based on dates of step turns in the rates of change—that is, dates when the rates of change "step" to higher or lower levels. The basic assumption of this method of analysis is that rates of change are punctuated by distinct jumps. The timing of steps in prices, wages, and output are related to corresponding reference cycle peaks and troughs. The selection of step cycles is done by a computer program and essentially follows the method used by Ilse Mintz in "Dating U.S. Growth Cycles,"

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Explorations, summer 1974, Vol. 1, No. 1. The advantage of timing comparisons based on step cycles is that they do not assume fixed leads or lags as do the commonly used regression methods based on fixed lag distributions.

The step turns in prices and wages generally appeared much later in the 1969–1970 cycle than in 1966–1967 or the two preceding cycles of the late 1950s and early 1960s. The median stepdown in prices for the fourteen industries occurred three quarters after the November 1969 business peak. The delayed turns are not attributable to longer lags between cycle downturns and each industry's downturn in output growth.

The magnitude of the price and wage steps, when they finally emerged after the 1969 peak, was just as large in absolute terms as it was in previous cycles, but somewhat smaller than in previous cycles as a percentage of the rates of price and wage increases registered before the turns, which were higher at the 1969 peak than at earlier peaks.

The results indicate that the apparently slow response of prices and wages to the 1970 recession was true in most manufacturing industries and reflected a longer lag but not, once the turn occurred, a smaller amplitude of step. Price controls had nothing to do with the longer lags in the steps down but did appear to delay the timing of the steps up in the business recovery of 1971 and 1972.

Phillip Cagan

The Behavior of Output and Input Prices

With a dynamic model of price and wage data we are integrating the long-run determinants of equilibrium price and wage rates with short-run disequilibrium factors operating in the commodity and labor markets. The wage and price equations derived from the model were estimated from data for the total economy, the total private economy, and fifteen two-digit manufacturing industries for the first quarter of 1954 to the second quarter of 1972. Price and wage forecasts were also generated for the aggregate sectors and manufacturing industries for the third quarter of 1972 to the second quarter of 1973. The basic results that emerged are the following: (1) Factor costs such as wage rates, rental prices of capital services, and material prices are important determinants of output price behavior in the aggregate and in individual industries. Their individual contributions, however, vary among the industries. (2) Aggregate spending influences prices significantly at both aggregate and industry levels. Thus, the structure of relative prices is not independent of changes in aggregate demand. (3) Capacity utilization affects prices negatively in the economy as a whole and in a large number of individual industries. This result, which differs from previous findings by other authors, suggests that the rise in the utilization rate—given the level of demand—represents a movement along the cost curve and leads to lower prices. (4) Long-term productivity growth and consumer prices play important roles in determining long-run wage rates. (5) There is a dynamic relationship between the wage rate and the unemployment rate—i.e., an acceleration in the unemployment rate affects the wage rate, but a change in the level of unemployment does not. (6) Price expectations are an important determinant of wage behavior; in many industries the long-run elasticity of wages with respect to expected prices is less than 1. (7) The guideposts affected the growth of wage rates in the aggregate and in many individual industries. (8) Short-run changes in productivity contribute significantly to the explanation of wage rate changes in several industries. Finally, the 1971–1973 controls seem to have affected mainly wages and not prices and were effective in Phase One; the results indicate that there was a catch-up effect after the controls were lifted.

This study was financed by a grant from the National Science Foundation.

M. Ishaq Nadiri

Measurement of Economic and Social Performance

Introduction

Over the past five years a group of NBER staff members has been actively engaged in research on extending the national income accounts to provide better measurements of

economic and social performance. In May 1972 a pilot project on this topic was formally funded by the National Science Foundation. It consisted of three major parts. The first examined a series of areas holding special promise for the development of a more welfare-oriented measure of national output and a more effective general framework of economic and social accounts, within which performance could be monitored. The second part involved exploring the possibility of extending the measurement of economic and social performance beyond the macroeconomic accounts to microdata. A methodology was developed for merging different microdata sets of information by identifying pairs of observations with sets of matching or common characteristics to create a synthetic file containing all the characteristics in both the original microdata sets. The third part of the project involved the valuation and analysis of time use and the development of a field experiment on the methodology of measuring time use.

Much of the early work of this group on the measurement of economic and social performance was presented to the Conference on Income and Wealth, and was published in *Studies in Income and Wealth*, volume 38, *The Measurement of Economic and Social Performance*, edited by Milton Moss. This included "A Framework for the Measurement of Economic and Social Performance," by Thomas Juster; "A Proposal for a System of Economic and Social Accounts," by Richard and Nancy Ruggles; and "The Measurement of Output of the Non-Market Sector: The Evaluation of Housewives' Time," by Reuben Gronau; as well as discussions by Robert Eisner and John Kendrick of a paper by Laurits Christensen and Dale Jorgenson on measuring economic performance in the private sector.

During the course of the pilot project, John Kendrick focused on imputations for non-market economic activities that are not included in the conventional income and product accounts. Much of this work was concerned with the extension of the concepts of tangible and intangible capital assets and the flows of services they yield. A series of publications appeared on this subject, including "The Treatment of Intangible Resources and Capital," *Review of Income and*

Wealth, March 1972; "The Accounting Treatment of Human Investment in Capital," *RIW*, December 1974; and *The Formation and Stocks of Total Capital,* now in press.

Robert Eisner was concerned with a variety of topics related to the measurement and analysis of "non-income income"—that is, aspects of what is functionally income but does not appear in conventional measures. He, like Kendrick, was concerned with estimating the flows of services and the accumulations of capital, both physical and human, used in producing those services. This led to extensive exploration of such questions as useful lives and depreciation of assets, as well as imputation of net rates of return. A manuscript on "A Total Income System of Accounts" was compiled as a possible framework for revised and expanded measures of income, product, and investment. Eisner was assisted by a number of students who were writing their dissertations on topics directly related to these matters.

Henry Peskin, assisted by Leonard Gianessi, focused on national accounting in relation to the environment: how to alter the income and product accounts to measure the flows of environmental assets and services. This involved taking into account, on the input side of each sector account, the services provided by air, water, and land to accommodate waste disposal needs, and deducting from the output side of each sector account an estimate of the value of the damage to affected persons resulting from the use of environmental assets. In principle, the damage is valued at what people would be willing to pay in order to avoid it. A paper on "The Distributional Implications of National Air Pollution Estimates" was presented by Henry Peskin, Leonard Gianessi, and Edward Wolff at the Conference on Research in Income and Wealth held in May 1974, and will be published in a forthcoming volume of *Studies in Income and Wealth.*

Richard and Nancy Ruggles, assisted by Edward Wolff, focused on techniques of combining microdata sets for households and persons. Three papers on methodology and strategy were published: "The Strategy of Merging and Matching Microdata Sets," *The Annals of Economic and Social Measurement,* April 1974;

"The Role of Microdata in National Economic Accounts," *The Review of Income and Wealth,* June 1975; and "Social Indicators and a Framework for Social and Economic Accounts," *Proceedings of the Social Statistics Section of the American Statistical Association,* 1974. In addition, three more analytical papers involving the use of microdata sets have also been prepared. Edward Wolff presented a paper at the Second Latin American Conference of the International Association for Resarch in Income and Wealth in Rio de Janeiro, January 1974, entitled "Social and Demographic Factors in the Distribution of Occupational Earnings." Nancy and Richard Ruggles presented a paper on "The Anatomy of Earnings Behavior" at the Conference on Income and Wealth in May 1974, which is being published in *Studies in Income and Wealth.* The paper by Peskin, Gianessi, and Wolff on air pollution damage, referred to above, relied on the use of microdata information arising from the pilot project as the basis for its estimates.

Milton Moss, assisted by Jane Duberg, was concerned with the lifetime distribution of income among persons and households, compiling data from a variety of sources on time paths of growth in total money income and/or earnings for individual age cohorts. The limitations of published aggregative data became apparent in the early stages of the pilot project, and the research has turned to microdata sets such as the Social Security Administration's LEED file, the Current Population Surveys, and the Public Use Samples.

Thomas Juster and Reuben Gronau focused on the measurement and valuation of time use by households and individuals. Gronau's work was concerned with the evaluation of women's economic performance in the non-market sector, and the incorporation of household economic activity, in particular the housewife's output, into the national accounts. This involved evaluating the housewife's price of time and analyzing inputs used in the household production process. In addition to the publication cited above, a paper, "Wage Comparisons—A Selectivity Bias," was published in the *Journal of Political Economy,* November/December 1974. Thomas Juster, together with John Robinson, investigated alternative ways of obtaining time

use measurements. A number of small-scale methodological studies were completed, with replications to insure the stability of findings.

The research undertaken in the pilot project on the measurement of economic and social performance demonstrated the need for, and the feasibility of, extending the national income accounts to include imputations for the services of tangible and intangible capital, environmental services and damages, and the use of time within the household. In addition, the development of microdata sets containing information from a variety of sources in a way that is consistent with the macroeconomic accounts was established as a feasible and useful technique for integrating social, demographic, and regional information into the measurement of economic and social performance. Since the pilot project was by its very nature an exploratory and experimental undertaking, the research activities of the various staff members were not designed to be closely coordinated, but in the course of the project it became evident (1) that the different parts of the project were in fact closely related and mutually interdependent, and (2) that the topics covered in the pilot project still left major gaps in the development of a comprehensive system of economic and social accounts that would provide the basis for measuring economic and social performance. Accordingly, a new project in this area was launched to continue the work in the areas that had proved fruitful and to fill in the major gaps that were found to exist. This new project began in October 1974 with NSF funding, and is expected to continue for three years.

Unlike the pilot project, the present project has been conceived of as a much more coordinated entity. It is intended to design and implement an extended macroeconomic accounting system, together with integrated microdata sets for individual sectors, that will be suitable for social and demographic as well as economic analysis. The various subprojects are all designed to contribute to this end. Richard and Nancy Ruggles, John Kendrick, Robert Eisner, and Henry Peskin are jointly developing the common set of extended macroeconomic accounts that will include the necessary imputations relating to the services of tangible and in-

tangible capital, environmental services and damages, and the use of time. This extended economic accounting system is being sectored in such a way that it provides the framework for microdata sets not only for households and individuals, but also for enterprises and governmental units. This step is taken in recognition of the fact that the analysis of the economic behavior of the system requires information on enterprises and governmental units, as well as households, and that the macro accounts by themselves cannot provide the required institutional and geographic dimensions.

In accordance with these decisions, the project is divided into two major parts: (1) the development and implementation of an extended macroeconomic accounting system, and (2) the development of microdata sets for enterprises, households, and governments. The substantive research of Kendrick, Eisner, and Peskin is concerned with the estimates necessary for implementing the extended macro framework. Kendrick is continuing to work on imputations arising from non-market activity, both in terms of services flowing from tangible and intangible capital and in terms of the services rendered by students, housewives, volunteers, and other non-market users of time. Eisner is focusing on problems of capital consumption charges relating to the expanded concept of capital, both tangible and intangible, including the revaluation of capital gains. Peskin continues to be primarily concerned with estimates of services and damage relating to air and water.

The work on microdata sets for the individual sectors of the economy has been considerably expanded. Nancy and Richard Ruggles, Milton Moss, and Edward Wolff continue to be concerned with the household sector. Nancy and Richard Ruggles are developing a macro household sector account that excludes nonprofit institutions, to which the microdata set for households can be aligned. Edward Wolff is carrying out the actual merging of a number of different microdata sets, using the techniques developed in the pilot project. He also is endeavoring to develop balance sheets for each household in the microdata set. Milton Moss is using the panel data from the Social Security Administration files and matched data from the 1960 and 1970 Public Use Samples to analyze lifetime patterns of income and earnings. With respect to the enterprise sector, Robert Lipsey and Michael Gort are extending their microdata sets of corporations and establishments. Since this aspect of the research was not covered in the pilot project, major questions of how this information is to be integrated into the expanded system of national economic accounts and related to other microdata sets are still unresolved. Similarly, the development of a microdata set for the government sector also constitutes a new area of research. This is being undertaken by John Quigley. He is using data from the Census of Governments to create a semi-microdata set for state and local governments that will show the sources of revenue and the types of expenditures of different governmental units by geographical area. Again, since this work has been recently initiated, the classifications for revenues, expenditures, and geographic units and their relation to the macro accounts and other data contained in the enterprise and household microdata sets are still in the early planning stages.

Finally, Thomas Juster at the Institute for Social Research is continuing to work on time use budgets on a collaborative basis. It is hoped that the information on time use budgets collected by ISR can be integrated with the household microdata set, and that it will also provide a better basis for the macro imputations of non-market activities.

Reports by the individual investigators on their activities follow.

Richard and Nancy Ruggles

Expanded Sector Accounts for Economic and Social Measurement

In conjunction with a subgroup of the other principal investigators we are working on expanding the national income accounts into a system of sector accounts suitable for the measurement of economic and social performance. These accounts (1) are to provide a conceptual framework for the project as a whole, covering not only national income accounting flows, including capital gains, but also imputations for non-market activity and environmental services

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and damage; and (2) are to provide the economic constructs with which microdata sets for the various sectors of the economy can be aligned. It is the microdata sets that contain the social, demographic, and regional information about the sectors.

In addition, we are working on implementation of the household sector account. For the household sector account to be compatible with the microdata set for households, nonprofit institutions must be excluded from the macrodata. This task has been faced by other research workers involved in the development of microdata sets, but it has not been carried out in terms of a full set of accounts that can be related to other sector accounts. The macro household sector accounts will also contain data for subsectors defined by economic and social characteristics. The subsectors contemplated include farm households, nonfarm proprietors' households, self-employed professionals' households, retired persons' households, wage and salary earners' households, and individuals living in institutions.

The development of subsector data at the macro level is predicated on the existence of an appropriate household microdata set. On the one hand, the microdata set must be aligned with the known totals for the household sector, as suggested above. Certain items in microdata sets tend to be underreported—e.g., transfer payments received by households—and the microdata file will have to be corrected so that it will add up to the known total. On the other hand, in order to create true subsectors it is necessary to use the microdata set for households to separate out the different kinds of households and to allocate the various types of income received to the different kinds of households. Thus, for example, farm income may be received by nonfarm families, and farm households may earn wages and salaries from nonfarm activities. The actual creation of the microdata set is being carried out jointly with Edward Wolff. At the present time major reliance is being placed on the 1969 and 1970 personal income tax models and the 1960 and 1970 Census Public Use Samples.

Richard and Nancy Ruggles

Expansion of Imputations in the U.S. National Income Accounts

After revising "The Formation and Stocks of Total Capital" for Directors' review, I have returned to extending and improving estimates of the imputed value of non-market activity for expanded national income accounts.

Imputations for a number of significant categories emerged as a by-product of the Total Capital study: imputed rentals on capital owned by households, private nonprofit institutions, and governments; business investments charged to current expense; and the opportunity costs of students of working age, and of the frictionally unemployed. These estimates, now available for the period 1929–1969, are being extended to 1973 with the assistance of Yvonne Lethem.

In addition, we are in process of revising and extending our estimates of the imputed values of unpaid household work, volunteer labor, and personal consumption of employees and the public financed by business through charges to current expense. Elizabeth Wehle plans to complete the estimates of unpaid household services by autumn, and we hope to have all the estimates done by year's end. We shall then turn our attention to analyzing the estimates and writing up the sources and methods.

John W. Kendrick

Measurement and Analysis of National Income

In this study I am concentrating primarily on capital accumulation and revaluation and depreciation of capital. I am assembling capital accumulation estimates by sector—enterprises, governments, and households—for tangible and intangible capital. Depreciation, which is of course sensitive to assumed methods and rates of life, is tied to revalued or market prices of capital. Where possible, it will be regarded as change, relating to the passage of time, in value of a given stream of anticipated returns at a given set of discount rates. Net revaluations involve the difference between actual changes in value of capital, aside from net investment, and the changes in value, as determined by an appropriate general price deflator, that would be necessary to keep real capital intact.

Work is proceeding currently on estimates of

income, product, capital, saving, and investment for households and government, including all capital and appropriate imputations. Work is also under way in developing a model and ultimately estimates of the effects of environmental controls and related considerations on value, longevity, and depreciation of capital.

Robert Eisner

National Accounting and the Environment

The object of this research is to impute to industrial, household, and governmental sectors the value of environmental assets and the associated value of environmental damage generated by the use of these assets.

Preliminary estimates have been made of the value of the atmosphere as a disposal medium and the associated damage attributable to the resulting air pollution. The value of air for disposal purposes has, as a first approximation, been estimated by the costs of reducing air pollution to harmless levels. These estimates were based primarily on EPA data and industry sources. The value of air pollution damage was also based on EPA data. In particular, EPA estimates of national damages were prorated to the sector of origin according to an index that accounted for local emission tonnages and population densities. Table II-2 on page 20 shows these preliminary costs and damage estimated for 1968 by two-digit SIC and natural sources.

It was necessary to include a natural sector to account for the significant contribution to total damage by natural sources of air pollution (erosion, wild fire, decay processes, etc.). In addition, a natural sector is required to "close" the theoretical accounting framework. The consolidated national income and product account requires, for consistency, a natural sector that "produces" all environmental asset services and "consumes" all environmental damages. In this system, consolidated GNP is equal to conventional GNP plus the "net production" of the natural sector. This net production, in turn, equals total environmental asset services less total environmental damage.

The principal focus of current research is to complete our measurement of the value of the disposal service provided by water bodies and the associated values of water pollution damage. Preliminary estimates of the costs of reducing water pollution are nearing completion. In addition, a project is under way to distribute national estimates of water pollution damage to geographical areas, to individuals, and to the generating sectors.

A paper reporting on project activities was presented at the Second National Symposium on Corporate Social Policy sponsored by the National Affiliation of Concerned Business Students in Chicago, Illinois, October 3–5, 1974. This paper "Accounting for the Environment," is forthcoming in *Social Indicators Research* (September 1975) pages 1-20.

Henry M. Peskin
Leonard Gianessi

The Short-Run Costs of
Water Pollution Abatement

The object of this research, which is supported by the Environmental Protection Agency, is to evaluate and, where possible, improve on EPA estimates of the short-run investment and annual costs of meeting the 1977 requirements of the Federal Water Pollution Control Act. There are about eighty industries facing restrictions on their discharges to waterways and to municipal sewage plants.

There are several ways by which EPA has estimated industry-wide treatment costs. For those industries in which the number of plants is small, treatment costs were estimated plant by plant. For most industries, however, EPA estimates the treatment costs of a "typical" or "model" plant and then multiplies by the number of plants in the industry to compute the total.

We have been able to improve the estimates. The cost of facilities in place has been netted out in order to estimate the incremental investment necessary to satisfy the EPA effluent guidelines. The estimates of production levels and numbers of plants in various industries have been updated and refined. We also estimated the charges municipalities levy for the sewered industrial wastes. Appropriate capital recovery formulas were applied to estimate annual costs.

As of this writing, we have completed preliminary analyses for about twenty-five industries.

TABLE II-2

Air Pollution Damage and Value of Disposal Service (1968),Preliminary Estimates .
(millions of 1970 dollars)

	Sector	Damage	% of Total Damage	Annual Cost to Meet EPA Standards [a]	% of Total Control Cost
01	Agriculture	241	1.2	1,137 [b]	5.4
07	Agricultural services	202	1.0	107	0.5
08	Forestry	835	4.1	160 [b]	0.8
10	Metal mining	15	0.1	19 [b]	0.1
11-12	Coal mining	92	0.4	161	0.8
13	Oil & gas drilling	25	0.1	8	—
14	Nonmetal mining	13	0.1	7	—
15-17	Construction	95	0.5	169 [c]	0.8
19	Ordnance	3	— [d]	3	—
20	Food products	133	0.7	55	0.3
21	Tobacco products	4	—	2	—
22	Textiles	56	0.3	19	0.1
23	Apparel	11	0.1	2	—
24	Wood products	36	0.2	63	0.3
25	Furniture	10	—	3	—
26	Pulp & paper	274	1.4	90	0.4
27	Printing, publishing	7	—	2	—
28	Chemicals	1,009	5.0	199	0.9
29	Petroleum products	1,474	7.3	207	1.0
30	Rubber products	88	0.4	11	0.1
31	Leather products	15	0.1	6	—
32	Stone, clay, glass	1,072	5.3	254	1.2
33	Primary metals	2,377	11.8	858	4.1
34	Fabricated metals	61	0.3	32	0.2
35	Machinery except electrical	55	0.3	16	0.1
36	Electrical machinery	45	0.2	10	—
37	Transportation equipment	96	0.5	27	0.1
38	Instruments	16	0.1	3	—
39	Miscellaneous manufacturing	21	0.1	3	—
40	Railroads	146	0.7	66 [b]	0.3
41	Local & suburban transit	139	0.7	165 [b]	0.8
42	Motor freight	121	0.6	133 [c]	0.6
44	Water transportation	198	1.0	49 [b]	0.2
45	Air transportation	42	0.2	274 [b]	1.3
46	Pipelines	16	0.1	34	0.2
49	Utilities	4,596	22.8	1,634	7.7
55	Gas stations	79	0.4	540 [b]	2.6
50-81	Trades and services	894	4.4	1,405 [c]	6.7
82	Education	18	0.1	67 [c]	0.3
88	Households	4,098	20.3	10,800 [c]	51.2
91-93	Governments	153	0.8	2,303 [c]	10.9
Natural		1,266	6.3	N.A.	N.A.
TOTAL		20,147	100.0	21,103	100.0

Note: N.A. = not applicable.

a. The primary data source was *The Economics of Clean Air*, Annual Report of the Administrator of the Environmental Protection Agency, March 1972. Many EPA cost numbers have since been revised upward. Many other sources (e.g., journal articles, contractors' reports, industry studies, etc.) were used to obtain the two-digit SIC breakdowns. Complete documentation on these sources and estimating methods is available from the project investigators.

EPA does not provide estimates of the costs to meet standards for fuel combustion from stationary sources broken down by sector. Therefore, aggregate EPA cost estimates are distributed by estimated fuel usage. EPA cost estimates, reflecting emission levels in 1977–1978 were adjusted to the 1968 base year by assuming a fixed proportion between a sector's activity level and its emissions.

b. EPA standards not established. Cost estimates are based on industry estimates of clean-up costs and EPA contractors' reports.

c. Estimate assumes all gasoline vehicles in 1968 are fitted with pollution control equipment necessary to meet 1977 standards.

d. Less than 0.1 percent.

We hope to use the data developed in this project as inputs to our study of National Accounting and the Environment.

Leonard Gianessi
Henry M. Peskin

The Development and Use of Household Microdata Sets

I have been primarily concerned with (1) developing a statistical technique for matching microdata sets with one another, (2) extending this statistical technique to the analysis of the occupational distribution of earnings, and (3) adding balance sheet information for individual households to the household microdata set.

With respect to matching techniques, I have been concerned with the econometric properties of a statistical match and have completed a manuscript, "The Goodness of Match," which proposes statistical procedures for evaluating the "fit" of a match of two data sets. If the variables in common in the two data sets are $X = (X_1, X_2, \ldots, X_n)$ and the non-overlapping variables in the first and second data sets are Y and Z, respectively, the true correlation between Y and Z is bounded by limits that are a function of the correlation of Y with each X_i and of Z with each X_i, the covariance matrix of X, and n, the number of common variables.

The statistical techniques used in the matching process have been applied to analyzing the occupational distribution of earnings. I am currently revising for publication a paper called "Social Determinants of Occupational Wage Behavior," in which I analyze the dispersion of income within each occupational class as a function of its composition. Based on a sample of 50,000 employed workers drawn from the 1960 and 1970 Public Use Samples, the study shows wide variation in the shape of the earnings distributions by occupation, although the inequality of income within occupation is, on the average, less than that of the economy as a whole. Much of the inequality is explained by differentials in earnings between whites and blacks, males and females, married and unmarried, and urban and rural workers. However, these occupational differentials are in general less than the economy-wide differential in earnings among the respective groups, since those groups with lower mean income tend to be concentrated at the bottom of the occupational ladder.

With respect to balance sheets, I have undertaken a project to examine how the composition of wealth by asset type varies by demographic group. The project involves the construction of a synthetic microdata base, the imputation of values to physical assets, and the capitalization of financial flows.

The first step is the statistical match of the 1970 IRS tax file with the 1969 tax file to transfer age, sex, and race data and certain kinds of liability information, such as mortgage payments. The second is a match of the extended 1969 tax file to a sample of 100,000 households drawn from the 1970 Census Public Use Sample. The resulting data set will provide data on the ownership of private homes, automobiles, televisions, and other consumer durables, and the receipt of capital gains, dividends, interest, and other financial flows by households. The third step is to impute a value to each of the consumer durables held, and for this purpose data from a consumer expenditure survey will be used. The fourth is to capitalize the financial flows, and for this purpose previous studies on the joint distribution of asset holdings and financial flows will be employed. The last is to align the totals by asset type in the micro sample with previously estimated totals from the FRB Flow of Funds data, Goldsmith's study on national wealth, and other wealth studies.

The resulting estimates will be useful in determining how portfolio composition varies by income level; household composition; age, sex, and race of the head of household; educational attainment; region and urban as against rural place of employment; and occupation and industry of employment of the head of household.

Edward N. Wolff

Lifetime Income

The lifetime income project is concerned with improved measures of lifetime income based on cohort data, principally from census and social security sources.

Cohort incomes are being related to growth in

GNP and productivity in order to provide measures of time period effects on the changes in income over the working life span and retirement for different sex and race groups. Income data by sources of income are also being developed. We are proceeding further in our measures of income dispersion as it develops over the life-span for different groups and types of income.

A major new extension of our work for these purposes is to test, at a micro level, estimates heretofore based on published aggregates. In cooperation with Richard and Nancy Ruggles, we are utilizing the data from the 1960–1970 censuses and the LEED file of the Social Security Administration to obtain improved measures of dispersion of lifetime income.

Preliminary results of our findings on cohort incomes and on changes in inequality as related to changes in economic growth were presented at a meeting of the New York Chapter of the American Statistical Association, April 17, 1975.

Milton Moss
Jane Duberg

A Microdata Set for Enterprises

Economists are accustomed to dealing with data for the enterprise sector as a whole, with data for industries, or with data for industries by geographic area. Yet it is not industries, but firms, that compile income statements and balance sheets, borrow and lend funds, and save or dissave. Production, on the other hand, is associated with establishments. Although establishments are linked to firms by ties of ownership, these ties are obliterated in our accounts when we aggregate establishments according to the type of product they make, as in the Census of Manufactures. If we try to retain ownership ties as the basis for our accounts, as in the *Statistics of Income,* industry lines become blurred because many companies own establishments in a variety of industries.

Classifying the enterprise sector by industry of establishments is not suitable for tracing many of the channels and impacts of economic change. For example, changes in corporate taxation affect companies, and thus affect establishments, individuals, and localities according to the ownership of the establishments rather than the industry to which they belong. Changes in foreign investment by American companies or foreign ownership of U.S. firms operate through channels of ownership rather than industry. Antitrust regulations or policies affecting conglomerates similarly exert their impact according to ownership, as do shifts in costs and availability of capital, since financial flows are associated with corporate ties. New technologies or management techniques are developed within corporations and spread through allied enterprises but do not necessarily move from one corporation to another in the same industry.

These considerations point to the need for development of a different type of information: microdata for individual corporations and individual establishments. In these data, location of individual plants and offices and their characteristics such as size, industry rate of growth, type of employee, etc., would be linked to the enterprises that control and finance them, and often provide technology or markets for them. Thus they would be tied to information on the size, rate of growth, technological input, financial characteristics, and foreign affiliations of these enterprises.

For several studies already under way at the National Bureau we have assembled financial data for approximately 2,000 industrial corporations. For those companies that are foreign investors we have matched the financial information to government data on each foreign affiliate, including income accounts, balance sheets, employment, sales, and other characteristics. We have also matched about 1,000 of the firms with data on the employment of each establishment, classified by detailed industry.

The first step in the new study has been to enlarge on the earlier data collection so as to increase our representation of manufacturing and to include firms outside manufacturing that we had omitted from our earlier data. We will then combine this enlarged set of financial data with several sources of information on employment in individual establishments, by industry and area. The combination will produce a distribution of each firm's employment by industry and location.

After this stage has been reached we will compare our industry-area aggregates with

those of the 1972 Census of Manufactures and other official counts both to reveal omissions in our data and to give us some information about the characteristics of establishments missing from our sample.

In later stages of the project we hope to incorporate additional establishment information on the characteristics of employees by sex, race, and broad occupational groups, and, for a smaller number of firms, information on R&D expenditures and employment.

The program for enterprise microdata differs in several respects from that for household microdata. The numbers of enterprises are smaller, a much higher proportion of income and assets is encompassed by a small number of observations, and the identity of individual enterprises is much more difficult to conceal than that of individual households. For the last reason, this data set at its fullest can never be made as freely available as some of the others, although large parts of it are public information and could be disseminated.

<div align="right">Robert E. Lipsey
Michael Gort</div>

An Expanded Government Sector in the National Accounts

In this part of the project, we are attempting to extend the government sector in the national accounts to develop a microdata set that includes information on the revenues and expenditures of local, state, and federal governments within geographic areas. The construction of this data set, which will consist of some 200 separate accounts for aggregates of central city, suburban, and rural governments by state, represents some compromise with the desire to gather and record revenue and expenditure detail at the micro level.

The government sector accounts will in general conform with those currently maintained on a consolidated basis for all governments. For each account, expenditures will be classified by program for each of the three levels of government. An attempt will be made to disaggregate expenditures into purchases of goods and services, compensation, transfers and interest, and grants in aid. The receipts of each level of government will be classified by type of tax or transfer program for local, state, and federal governments. These accounts, aggregated over the 200 micro units, will be aligned with the consolidated accounts of the three sectors recently completed by analysts at the Department of Commerce.

Upon completion, this set of semi-micro accounts for the government sector will allow for a more complete analysis of the fiscal relationships among levels of government and will permit the impacts of revenue and expenditure policies to be traced to the affected local governments and their residents. At a later stage of development, we anticipate combining or matching the microdata set for households to this microdata set for governments to get a more complete understanding of the relationships between the fiscal policies of different governmental units and the behavior of households.

<div align="right">John M. Quigley</div>

Business Cycles

Introduction

Questions about the business cycle came to the fore again during 1974. Was the nation entering upon a recession? If so, when did it begin? How serious was it? Why was inflation continuing at such a strong pace? Would the recession, sooner or later, snuff out the inflation? Why did economic forecasters, on the whole, anticipate neither the strength of inflation nor the severity of recession during 1974?

Studies carried on during the year contributed information pertinent to each of these questions. In January 1974 we began to make detailed comparisons of the behavior of significant economic indicators during previous recessions with their behavior since November 1973, on the assumption that that month might prove on later examination to have been the business cycle peak. For many months thereafter the assumption was in doubt. Although unemployment rose to levels approaching those in earlier recessions, total employment also rose, contrary to its behavior in earlier recessions. Although GNP in constant dollars declined as much as in some earlier recessions, the decline in industrial pro-

duction was smaller than in even the mildest of previous recessions. Although profits according to conventional measures, contrary to their behavior in previous recessions, kept on rising, profits according to measures that allowed for the effect of inflation on inventory values fell sharply. Although some industries, such as steel, operated under boom-like conditions through most of the year, others, such as housing construction, dropped into a very depressed state.

Despite these contradictions, the level of aggregate economic activity, in physical terms, did not appear to regain the level reached in 1973 and further deterioration in the fall of 1974 clinched the matter (see Figure II-1). Accordingly, the original choice of November 1973 as the business cycle peak was confirmed. A record of this experiment in measuring business cycles contemporaneously was prepared by Moore in December 1974 and appeared in the spring 1975 issue of *Explorations in Economic Research,* Vol. 2, No. 2. The report is entitled "Slowdowns, Recessions, and Inflation: Some Issues and Answers."

Apart from the question when the recession began, the report also deals with its relative severity vis-à-vis earlier recessions back to the 1920s. It concludes that, at least in terms of data available through February 1975, the current period resembles the 1957–1958 contraction more closely than the severe contractions of the twenties and thirties. Another topic dealt with, as the title suggests, is the behavior of the rate of inflation during periods identified as "growth cycles" in Ilse Mintz's recently published work ("Dating U.S. Growth Cycles," *Explorations in Economic Research,* Vol. 1, No. 1, summer 1974). We find a one-to-one correspondence between periods of rapid growth and rising rates of inflation, alternating with periods of slow growth (or decline) and falling rates of inflation. The latest period of slow growth (and decline) dates from March 1973; evidence is developed in the report that the high point in the inflation rate may have been reached in October 1974—a lag of nineteen months. Lags of similar length characterized the preceding slowdown (1969–1970) and appear to be associated with lags in the rate of unemployment and also with the tendency investigated by Phillip Cagan for wholesale

prices to be less responsive to slack demand in recent than in earlier recessions (see Cagan's report in Section 1).

Several other papers dealing with various aspects of the recession and inflation were prepared by Moore: "The State of the International Business Cycle," in *Business Economics,* September 1974; "New Light on Real Earnings," in the *Wall Street Journal,* December 4, 1974; "Recession-related Unemployment," in the *New York Times,* January 19, 1975 (an expanded version was issued by the American Enterprise Institute, Reprint 29, March 1975); and "Employment and Unemployment as a Guide to Full Employment," to be published in the Proceedings of the Conference on Full Employment, Hunter College, February 1975 (also in the *Wall Street Journal,* May 9, 1975). Walter Ebanks has constructed a new index of the physical volume of economic activity based entirely on measures that are expressed in physical units. One of its uses is to provide a comparison with measures expressed in dollars deflated for price changes, because of the difficulty in appraising the accuracy of the price deflators when prices are changing rapidly, as they were in 1974. A description of the index is given in his paper, "A New Index of the Physical Volume of Economic Activity," *Business Economics,* May 1975. See also line 8 in Figure II-1.

A definitive account of the errors in economic forecasts for 1974, which surpassed those of most prior years by a wide margin, has yet to be written. Two background reports that throw some light on the problem, however, were prepared, and two new studies are under way that will put us in a better position to evaluate sources of error and to reduce them. The report by Vincent and Josephine Su, "An Evaluation of the ASA/NBER Business Outlook Survey Forecasts," sets forth the record of forecasts by the fifty to sixty economists who regularly participate in the quarterly survey conducted by the American Statistical Association and the National Bureau. The report will appear in *Explorations in Economic Research,* Vol. 2, No. 4, fall 1975. A brief paper by Moore comparing this record of private forecasts with those in the Economic Report of the President was published in the *Morgan Guaranty Survey,* January 1975, under

Figure II-1

Cyclical Peaks in the Physical Volume of Aggregate Economic Activity, 1971–1974
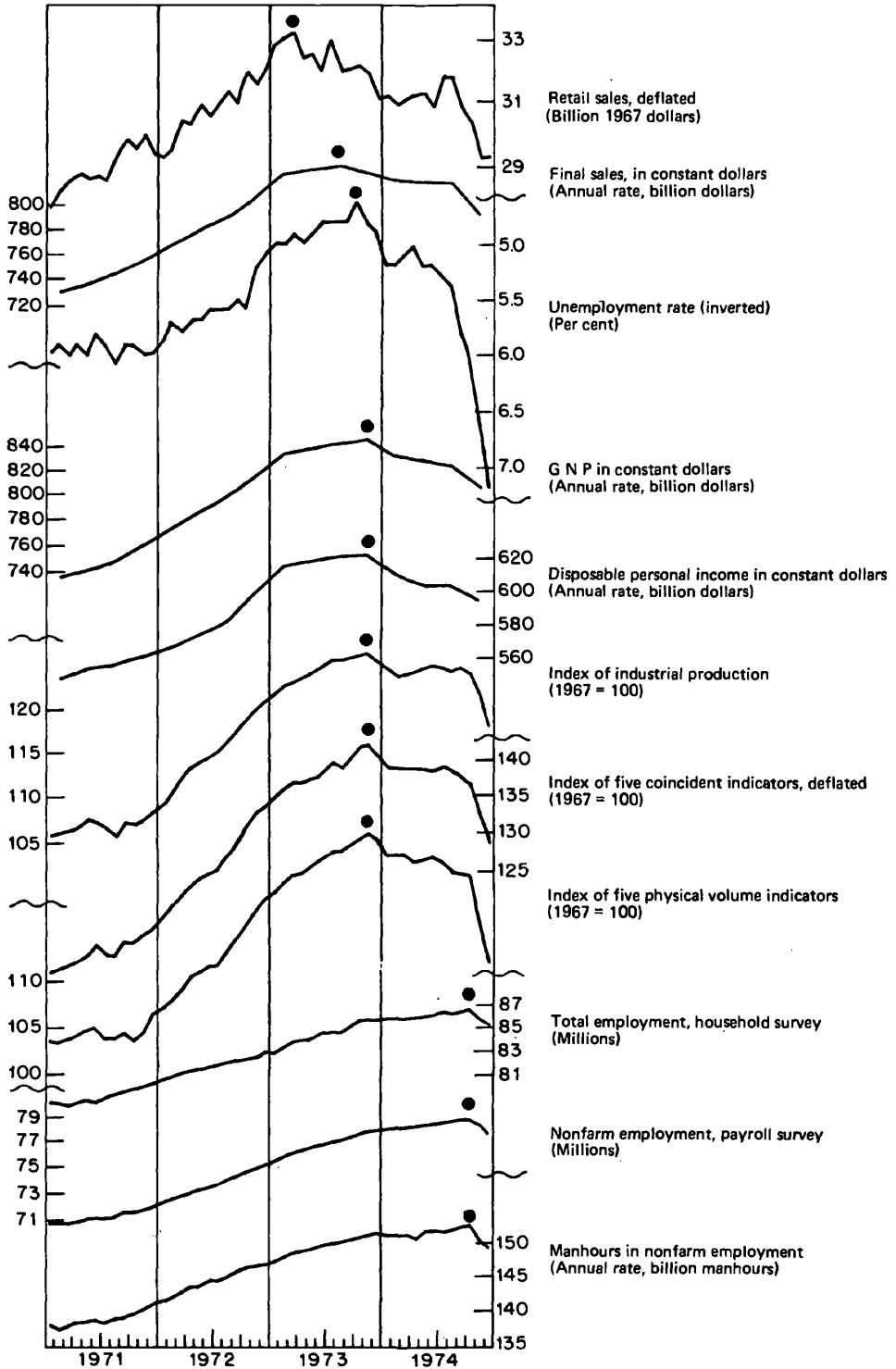
Note: ● = Specific cycle peak.

the title, "Economic Forecasting—How Good a Track Record?" A study designed to evaluate the forecasting performance of several econometric models got under way in September 1974 under the direction of Phoebus J. Dhrymes and Victor Zarnowitz. Problems in the measurement of inventories, one of the great concerns of forecasters during 1974, are being attacked in a study directed by Murray Foss, Gary Fromm, and Irving Rottenberg. Plans for both these new studies are reported below.

Some new tools for economic forecasting have been forged by Zarnowitz and Charlotte Boschan in their study of economic indicators for the Bureau of Economic Analysis, U.S. Department of Commerce. Among the products are new indexes of leading, coinciding, and lagging indicators and updated measures of the cyclical performance of a large number of individual indicators. They carefully reviewed the previously established chronology of business cycles and made a few relatively minor changes, set forth in their report below. A general description of the uses of economic indicators was given in Moore's "The Analysis of Economic Indicators," *Scientific American,* January 1975.

One of the more consistent of leading indicators examined in the Zarnowitz-Boschan study is stock prices. For example, the decline in stock prices that began in January 1973 started two months before the peak in the growth cycle (March 1973) and ten months before the peak in the business cycle (November 1973). That there was nothing unusual about these leads is evident from the historical record analyzed in "Security Markets and Business Cycles" (*Financial Analysts Handbook,* 1975), and "Stock Prices and the Business Cycle," *Journal of Portfolio Management,* April 1975. These essays by Moore attempt to account for the persistent lead in stock prices by the behavior of corporate profits and interest rates, two of the factors that traditionally have been held to have a determining influence on the equity market.

Desmond O'Dea's paper on "The Cyclical Timing of Labor Market Indicators in Great Britain and the United States," which demonstrates a marked similarity in the leads and lags of matching labor market indicators in the two countries, was published in the winter 1975 issue of *Explorations in Economic Research,* Vol. 2, No. 1.

Walter Ebanks' paper on "The Stabilizing Effects of Government Employment," which shows that some of the effects, particularly in the federal sector, have not been so stabilizing as is commonly supposed, is being reviewed by the staff.

Other reports on research in business cycles follow.

Geoffrey H. Moore

Cyclical Indicators

The study on evaluation of cyclical indicators, financed by a contract between the Bureau of Economic Analysis (BEA), U.S. Department of Commerce, and Victor Zarnowitz, is nearing completion. Apart from the comprehensive review of a large number of indicators, the study will yield new composite indexes and a new "long list" of all accepted indicators, cross-classified by characteristic timing at peaks and at troughs, and by economic process. The results will be used to revise *Business Condition Digest (BCD),* a monthly publication of BEA. A new composite index of indicators leading at both peaks and troughs of business cycles has been published in Zarnowitz and Boschan, "Cyclical Indicators: An Evaluation and New Leading Indexes," *BCD,* May 1975. Table II-3 compares the composition of the new index with the old and lists the reasons for changes. A comprehensive report on the study will be published later.

In connection with this study we undertook a review of the NBER Reference Chronology for the postwar period. The review was prompted by the revision of some aggregate time series and the availability of some new ones—particularly better deflated data. It resulted in a few small and scattered revisions of dates.

For this purpose a set of the principal available measures of aggregate income and expenditures, value of output and sales, volume of production, employment, and unemployment was closely analyzed. Since these aspects of general economic activity admit of different measurements and their alternative statistical representations contain largely unknown data errors, two or more related or partially over-

TABLE II-3

Relation Between the New Composite Index of Leading Indicators and the Old Index

Series in New Index[a]	Series in Old Index[a]	Reason for Change
Average workweek of production workers, manufacturing (I)	Same (I)	N.A.
Index of net business formation (IV)	Same (IV)	N.A.
Index of stock prices, 500 common stocks (VI)	Same (VI)	N.A.
Index of new building permits, private housing units (IV)	Same (IV)	N.A.
Layoff rate, manufacturing (inv.) (I)	Average weekly initial claims for unemployment insurance (inv.) (I)	Layoff rate leads more consistently at troughs; classified L,L,L. Initial claims classified L,C,L.
New orders, consumer goods and materials, 1967 dollars (III)	New orders, durable goods (III, IV)	New series avoids duplication with orders for equipment. Deflation needed for better cyclical performance since the late 1960s.
Contracts and orders for plant and equipment, 1967 dollars (IV)	Same, current dollars (IV)	Deflation needed for better cyclical performance since the late 1960s.
Net change in inventories on hand and on order, 1967 dollars (smoothed) (V)	Change in book value, manufacturing and trade inventories (V)	Concept of including stocks on order is better. Deflation is needed for better cyclical performance since the late 1960s.
Percent change in sensitive prices, WPI crude materials excluding foods and feeds (smoothed) (VI)	Index of industrial materials prices (VI)	Percent change is better than level. Leads are more consistent, especially since the late 1960s.
Vendor performance, percent of companies reporting slower deliveries (III)	—	Best available indicator of changes in delivery lags. Good record of timing and conformity.
Money balance (MI), 1967 dollars (VII)	—	Important measure of the quantity of money in real terms. Good scores for indicator performance.
Percent change in total liquid assets (smoothed) (VII)	—	Comprehensive measure of changes in wealth held in liquid form by private nonfinancial investors.
—	Corporate profits after taxes (VI)	Quarterly and tardy (low score for currency).
—	Change in consumer installment debt (VII)	Lacks timeliness. In recent period, very erratic and more nearly coincident than leading at troughs.
—	Ratio, price to unit labor cost, manufacturing (VI)	Fails to lead at the last three troughs in (1958–1970). Work continues on developing a satisfactory substitute.

Note: N.A. = not applicable.

a. The type of economic process for the indicators is indicated by roman numerals in parentheses as follows: I. employment and unemployment; III. consumption, saving, and distribution; IV. fixed capital investment; V. inventory and inventory investment; VI. prices, costs, and profits; VII. money and credit.

lapping series were used for some of the processes. The whole set consists of twelve series in real terms and seven series in current dollars, as identified in Table II-4, notes c and d.

Several methods of distilling the relevant evidence were applied to this selection of indicators: measurement of central tendency and dispersion for each cluster of specific cycle turns corresponding to the successive recessions and recoveries, composite (amplitude-adjusted) indexes, cumulative diffusion indexes, and comparisons with alternative chronologies.

TABLE II-4

Timing Comparisons With Revised Reference Dates of U.S. Business Cycles,1948–1973

Dates of Peaks (P) and Troughs (T) in U.S. Business Cycles			Lead (–), Lag (+), or Coincidence (0) in Months, at the Revised Reference Dates			
	Revised Reference Dates (1)	Previous Reference Dates [a] (2)	Nineteen Indicators [b]		Twelve Real Indicators,[c] Composite Index (5)	Seven Nominal Indicators,[d] Composite Index (6)
			Composite Index (3)	Median Timing (4)		
P	Nov. '48	Nov. '48	0	–2	0	–1
T	Oct. '49	Oct. '49	0	0	0	0
P	July '53	July '53	0	–2	–4	–2
T	May '54	Aug. '54	0	0	0	0
P	Aug. '57	July '57	0	0	–5	0
T	Apr. '58	Apr. '58	0	–1	0	0
P	Apr. '60	May '60	+1	0	0	0
T	Feb. '61	Feb. '61	0	0	0	0
P	Dec. '69	Nov. '69	N.T.	0	–4	N.T.
T	Nov. '70	Nov. '70	N.T.	0	0	N.T.
P	Nov. '73		+9	0	0	+9
			Mean Lead (–) or Lag (+) in Months			
Mean, regarding signs			+1.1	–0.5	–1.2	+0.7
Mean, disregarding signs			1.1	0.5	1.2	1.3

Note: N.T. = no turning point.

a. The standard NBER business cycle chronology as established before the present revision.

b. Includes the series listed in notes c and d below.

c. Number of employees on nonagricultural payrolls; number of persons engaged in nonagricultural activities; index of industrial production; manhours in nonagricultural establishments; manufacturing and trade sales, 1967 dollars; retail store sales, 1967 dollars; total civilian employment; number of persons unemployed (inverted); personal income, 1967 dollars; GNP, 1958 dollars (Q); final sales, 1958 dollars (Q); GNP gap, 1958 dollars (Q) (inverted).

d. Personal income; wages and salaries in mining, manufacturing, and construction; sales of retail stores; manufacturing and trade sales; GNP (Q); final sales (Q); value of goods output (Q).

Some of the results are summarized in Table 11-4. Two peak dates (1957 and 1969) were shifted forward, and one (1960) backward, in each case by one month, and one trough date (in 1954) was shifted backward by three months; the dates of the other two peaks and four troughs of U.S. business cycles in the 1948–1970 period remain unchanged.

There is a one-to-one correspondence between the specific cycles in the indexes for the real and the nominal subsets of the indicators up to 1970, and the evidence generally supports the historical use of measures for both groups in identifying and dating business cycles (cf. Table II-4, columns 2–5). However, in 1970 the indexes compiled from the current dollar data

registered only retardations and short declines; the peak and trough dates of that cycle were based primarily on the cyclical turns in the real indicators. For the latest peak, which is dated in November 1973, all the evidence is not in yet, but it appears now that the nominal series will show a contraction, albeit considerably later than the real series.

Even during the 1970 contraction some of the important individual nominal series did decline, and the distributions of all timing observations available for the nineteen indicators provide supporting evidence (see Table 11-4, column 4). On such occasions, the *dating* of the recessions and recoveries must obviously rely mainly (but not necessarily exclusively) on the group of in-

dicators in real terms, although the changes in prices and nominal aggregates must be included in any attempt to *describe* or *explain* these cyclical movements adequately.

<div align="right">Victor Zarnowitz
Charlotte Boschan</div>

International Economic Indicators

The International Economic Indicators project was launched at the National Bureau in August 1973. One of its basic purposes was to broaden the focus of recent NBER cyclical research from primarily (though not exclusively) U.S. cycles to "nations that organize their work mainly in business enterprises." The latter was the perspective taken by Burns and Mitchell in their well-known definition of business cycles (1946). Although research on cycles outside the United States and on the transmission of fluctuations from one country to another has by no means been entirely neglected (as evidenced by the work of Friedman and Schwartz, Michaely, Mintz, and Morgenstern), the major thrust at the Bureau in the past quarter century has been on improving our analytical and predictive techniques as they pertain to business cycles in the United States.

The IEI project has been sponsored by grants from the Department of Commerce, from the American Enterprise Institute, and from the Scherman Foundation, as well as by general funds of the National Bureau. Its initial objective was to see whether the system of leading, coincident, and lagging indicators developed by the National Bureau and now published currently in *Business Conditions Digest,* the monthly publication of the Department of Commerce, could be duplicated for a number of market-oriented economies outside the United States. The project has built on the work on growth cycles by Ilse Mintz for Germany and more recently for the United States. Recognizing that postwar cycles have frequently taken the form of deviations from trend or slowdowns in growth rather than absolute declines in economic activity, as was customarily the case before World War II, Mrs. Mintz developed a technique for measuring "growth cycles" (as opposed to "classical cycles") in which turning points are

selected in trend-adjusted time series.

The initial questions which the IEI project posed for itself, therefore, can be summarized as follows: (1) Is the notion of a growth cycle a useful approach to the study of cyclical instability in a number of market-oriented economies— i.e., can growth cycle chronologies be established in a comparable manner for a number of market-oriented economies? (2) Can rough equivalents for the U.S. leading and lagging indicators of classical cycles be found for other countries and if so do they exhibit comparable tendencies to lead or lag growth cycle turning points abroad?

The first task of the IEI project during the past year was to devise a workable adaptation of the NBER's computer program for classical cycles to the demands of analyzing trend-adjusted data. The basic requirement was to devise a trend-fitting technique that would work on series of varying length containing shorter cyclical movements of varying duration, and that could be brought up to date without extensive revision of earlier results. The technical difficulties in developing this program were complex but have at last been largely overcome, with the result that the project is now in a position to move forward more rapidly. The first priority has been given to analyze the data collected for the United Kingdom, Canada, Japan, and West Germany. Other countries for which data have been collected and added to our data bank include France, Italy, Austria, Belgium, the Netherlands, Denmark, Ireland, and Sweden. Still other countries, including Australia and Finland, have expressed interest in being included in the project.

The computer program is being used initially to develop growth cycle chronologies for other countries. Thus far the project has produced such chronologies for the United Kingdom, Japan, and Canada. The results, together with the chronologies developed by Ilse Mintz for West Germany and the United States, are shown in Table II-5 and Figure II-2.

These chronologies represent a considerable step forward in our ability to analyze international instability. For example, there is the often heard comment that "when the United States sneezes Europe catches cold." The table and chart suggest quite clearly that whatever may have been

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TABLE II-5

Growth Cycle Chronologies, Five Countries, and Lags (+) and Leads (−) vs. United States

Peak	Trough	United States[a] P	United States[a] T	United Kingdom[b] P	United Kingdom[b] T	West Germany[c] P	West Germany[c] T	Japan[b] P	Japan[b] T	Canada[b] P	Canada[b] T
P		8/48									
	T		11/49								1/50 (+2)
P		5/51		5/51 (0)		4/51 (−1)					
	T		7/52		11/52 (+4)		1/54 (+18)*				
P		3/53						1/54 (+10)		11/52 (−4)	
	T		9/54						6/55 (+9)		10/54 (+1)
P		2/57		12/55 (−14)		1/56 (−13)		5/57 (+3)		11/56 (−3)	
	T		5/58		11/58 (+6)		3/59 (+10)		2/59 (+9)		6/58 (+1)
P		2/60								10/59 (−4)	
	T		2/61								2/61 (0)
P		4/62		3/61 (−13)		1/61 (−15)*		11/61 (−5)		3/62 (−1)	
	T		4/63		2/63 (−2)		2/63 (−2)		12/62 (−4)		8/63 (+4)
P		6/66		2/66 (−4)		12/65 (−6)		8/64 (n.c.)		3/66 (−3)	
	T		10/67		3/67 (−7)		6/67 (−4)		2/66 (n.c.)		2/68 (+4)
P		6/69		11/68 (−7)				3/70 (+9)		3/69 (−3)	
	T		11/70		2/72 (+15)				3/72 (+16)		12/70 (+1)
P		3/73									

Summary

|	UK P	UK T	WG P	WG T	Japan P	Japan T	Canada P	Canada T
Number of leads	4	2	4	2	1	1	6	0
Number of coincidences	1	0	0	0	0	0	0	1
Number of lags	0	3	0	2	3	3	0	6
Mean lead (−) or lag (+)	−7.6	+3.2	−8.8	+5.5	+4.2	+7.0	−3.0	+1.9

Note: n.c. = no timing comparison.
* Crosses opposite turn.
a. Ilse Mintz, "Dating United States Growth Cycles," *Explorations in Economic Research*, Vol. 1, No. 1, summer 1974, p. 59.
b. IEI Project, March 6, 1975.
c. Ilse Mintz, *Dating Postwar Business Cycles: Methods and Their Application to Western Germany, 1950–67* (New York: National Bureau of Economic Research, 1969).

Figure II-2

Growth Cycle Chronologies, Five Countries, and Leads (−) and Lags (+) vs. United States
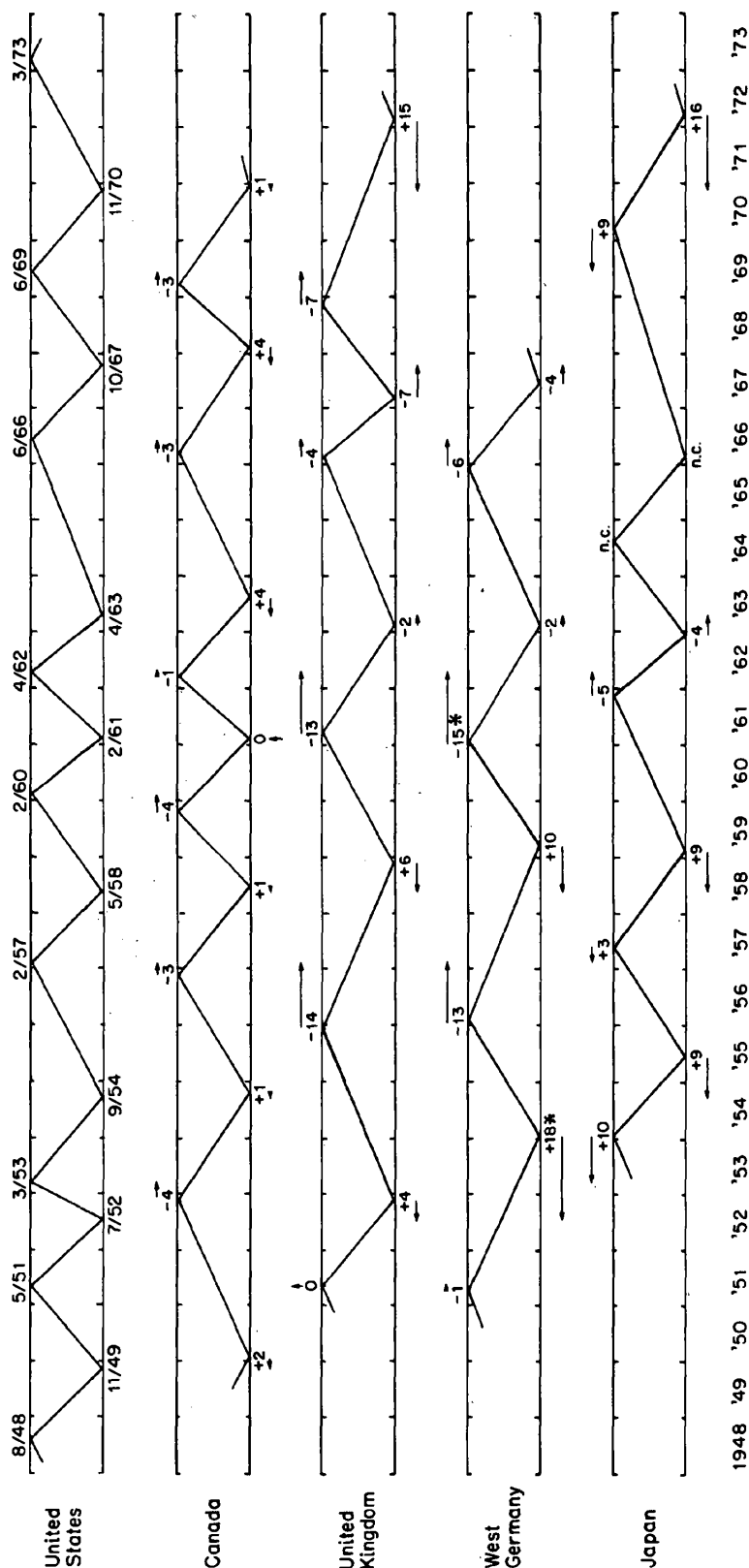
Note: Arrowed figures represent lead (−) or lag (+), in months, vis-à-vis U.S. growth cycle turn.

* Timing comparison crosses opposite turn.

n.c. = no timing comparison.

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the case before World War II, during the postwar period there is very little evidence to support the "sneeze hypothesis" with respect to growth cycle peaks. The U.S. peaks lagged most peaks in the United Kingdom, West Germany, and Canada (in fact, all the Canadian peaks preceded the U.S. peaks). Only in the case of Japan is there evidence corroborating the "sneeze hypothesis." At troughs the picture is less clear —U.S. troughs preceded troughs in the United Kingdom three times, in West Germany twice, in Japan three times, and in all the Canadian troughs. Thus the chronologies suggest a tendency, at least in a significant number of cases, for other countries to lead the United States into growth recession and for the United States to lead other countries into recovery. Whatever our ultimate assessment of this evidence may be— and more work must be done on it—the summary results of Table II-5 and the data underlying it are indicative of the new avenues opened up by the IEI project.

Work thus far strongly supports, therefore, the feasibility of developing growth cycle chronologies for a number of market-oriented economies. It suggests, too, the value of maintaining these chronologies on a current, comparable basis with current information gathered by a single agency. Since our efforts to assemble matching lists of leading, coincident, and lagging indicators for other countries also have proved quite successful, we have proceeded to test whether their behavior in other countries at growth cycle turning points conforms to their behavior in the United States.

The United Kingdom was the first country for which this test was completed, and a report on the results, "Postwar Growth Cycles in the United Kingdom—An Interim Report," by Philip A. Klein, is being readied for publication. Working with a preliminary chronology of growth cycle turning points, and with the generous assistance of the British Central Statistical Office, the study analyzed the behavior of the U.K. equivalents to the U.S. leading, coincident, and lagging indicators at postwar U.K. growth cycle turning points. Subsequently we duplicated this analysis for Japan and Canada and find that the types of indicators that lead in the United States also lead in each of the three countries, whereas those that lag in the United States also lag abroad. Tables II-6, II-7, and II-8 show that this

TABLE II-6

Median Timing Patterns at British Growth Cycle Turns, 1951–1972,
26 Indicators Matching U.S. Short List

[Median Lead (–) or Lag (+), In Months, at Growth Cycle Peaks (P) and Troughs (T)]

	P 5/51	T 11/52	P 12/55	T 11/58	P 3/61	T 2/63	P 2/66	T 3/67	P 11/68	T 2/72	Average (mean) at		
											P	T	P & T
6 Lagging indicators, inverted [a]	n.a.	n.a.	–20	–33	–25	–21	–27	–7	–12	–15	–21.0	–19.0	–20.0
13 Leading indicators	n.a.	n.a.	–5	–5	–12	–3	–17	–2	–4	–9	–9.5	–4.8	–7.1
7 Roughly coincident Indicators	0	0	0	0	–1	0	0	0	0	–1	–0.2	–0.2	–0.2
6 Lagging indicators	n.a.	+17	+2	+3	+2	+9	+6	+8	+24	n.a.	+8.5	+9.2	+8.9

Note: n.a. = not applicable.

a. Median peaks in lagging group are compared with growth cycle troughs, and median troughs are compared with growth cycle peaks.

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TABLE II-7

Median Timing Patterns at Japanese Growth Cycle Turns, 1954–1972,
24 Indicators Matching U.S. Short List

[Median Lead (–) or Lag (+) in Months at Growth Cycle Peaks (P) and Troughs (T)]

	P 1/54	T 6/55	P 5/57	T 2/59	P 11/61	T 12/62	P 8/64	T 2/66	P 3/70	T 3/72	Average (mean) at		
											P	T	P & T
5 Lagging indicators, inverted[a]	n.a.	–16	–13	–18	–12	–13	–18	–15	–9	–19	–13.0	–16.2	–14.8
11 Leading indicators	–1	–7	0	–6	–4	–1	–8	–5	–2	–4	–2.6	–1.8	–2.4
8 Roughly coincident indicators	+1	+1	0	0	0	0	0	0	–1	–1	0	0	0
5 Lagging indicators	+1	+10	+3	+21	0	+2	+3	+18	+5	+5	+2.4	+11.2	+6.8

Note: n.a. = not available.
a. Median peaks in lagging group are compared with growth cycle troughs, and median troughs are compared with growth cycle peaks.

TABLE II-8

Median Timing Patterns at Canadian Growth Cycle Turns, 1950–1970,
27 Indicators Matching U.S. Short List

[Median Lead (–) or Lag (+) in Months at Growth Cycle Peaks (P) and Troughs (T)]

	T 1/50	P 11/52	T 10/54	P 11/56	T 6/58	P 10/59	T 2/61	P 3/62	T 8/63	P 3/66	T 2/68	P 3/69	T 12/70	Average (mean) at		
														P	T	P & T
6 Lagging indicators, inverted[a]	n.c.	–30	–20	–21	–16	–13	–15	–10	–17	–34	–11	–8	–10	–19.3	–14.8	–17.1
13 Leading indicators	–2	+6	–5	–9	–6	–3	–4	–1	–10	–16	–7	+2	+1	–3.5	–4.7	–4.1
8 Roughly coincident indicators	+4	–6	0	0	0	0	+1	–1	0	–1	0	0	0	–1.3	+0.7	–0.2
6 Lagging indicators	+4	+3	+4	+3	+3	+1	+3	0	–3	+12	+5	+11	+10	+5.0	+3.7	+4.3

Note: n.c. = no timing comparison.
a. Median peaks in lagging group are compared with growth cycle troughs, and median troughs are compared with growth cycle peaks.

sequence is followed not only on the average but also in nearly every observable instance. Recently completed work on the West German indicators shows similar results. This four-country record is all the more remarkable because the indicators were selected and classified according to their performance in the United States, without reference to their performance abroad.

Finally, working with data on U.S. foreign trade, we have been able to explore tentatively the relationships between foreign and domestic growth cycles and their relative importance in affecting international trade. One important question is whether the growth of U.S. exports improves or deteriorates in line with changes in the phase of the growth cycle in other countries. Table II-9, Part A, suggests that the answer is an emphatic yes. Part B supplies a similar answer to the question whether other countries' exports to the United States (i.e., U.S. imports) conform to U.S. growth cycles. It is evident, then, that knowledge of the current state of the growth cycle in each country, which is one of the objectives of developing leading indicators of such cycles, should be of material aid in analyzing foreign trade trends and the competitive position of trading partners.

In summary, our preliminary results are encouragingly supportive of the feasibility of the IEI project and of the appropriateness of its underlying hypotheses. Comparable growth cycle

TABLE II-9

Changes in U.S. Exports and Imports During Growth Cycles

A. Changes in Exports During Foreign Growth Cycles					
	Average Number of Months in Foreign Growth Cycle		Average Change per Month in U.S. Exports During Foreign Growth Cycle		Conformity Index
U.S. Exports to:	Upswings	Downswings	Upswings	Downswings	
Japan, 1959–1972	34	18	+2.74	−0.32	+100
United Kingdom, 1958–1972	28	25	+1.43	+0.25	+100
West Germany, 1959–1967	28	22	+1.11	+0.11	+33
Canada, 1958–1970	18	19	+4.00	+1.68	+71

B. Changes in Imports During Domestic Growth Cycles					
	Average Number of Months in U.S. Growth Cycle		Average Change per Month in U.S. Imports During U.S. Growth Cycle		Conformity Index
U.S. Imports from:	Upswings	Downswings	Upswings	Downswings	
Japan, 1958–1973	24	14	+5.41	+1.46	+100
United Kingdom, 1958–1973	14	14	+2.14	−0.50	+100
West Germany, 1958–1973	24	14	+2.33	+0.99	+50
Canada, 1958-1973	24	14	+7.81	+3.60	+75

NOTE: All figures on exports and imports are in millions of dollars, based on monthly seasonally adjusted data. Changes during upswings and downswings are measured from three-month averages centered on growth cycle peaks and troughs. For growth cycle chronologies, see Table II-5. A slower rate of growth during a growth cycle downswing than in an adjacent upswing is counted as an instance of positive conformity, the opposite as negative conformity. The number of positive instances minus the number of negative instances, divided by the total number, times 100, is the conformity index. It can range from +100 to −100.

chronologies can be constructed for other countries and techniques developed for classical cycle analysis can be adapted to growth cycle analysis. The timing classifications of important economic processes developed in the United States with data pertaining to classical cycles can provide a fruitful launching pad for the development of leading, coincident, and lagging indicators of growth cycles in other countries. Finally, the development of comparable chronologies and indicators for a number of countries represents a promising way of furthering our understanding of how cyclical instability is transmitted internationally as well as adding to our understanding of the cyclical process domestically.

In order to place the analytical results of our studies into a framework whereby they can be used on a current basis, we have developed a prototype for a publication similar to *Business Conditions Digest* but devoted to international economic indicators. Further refinements in this prototype will be incorporated as our research progresses. In addition, we have begun to prepare a basic volume that will endeavor to establish in terms of substantive findings the validity of applying the concepts of growth cycles and lead-lag indicators on an international scale.

Geoffrey H. Moore
Philip A. Klein

Monetary Trends in the United States and the United Kingdom, 1880–1970

During the past year we completed a draft of Chapter 9 of our manuscript. The chapter deals with the division of change in nominal income in the two countries between prices and output. Until World War I, the rate of change in both prices and output was less variable in the United Kingdom than in the United States. Thereafter, the rate of price change varied more widely in the United Kingdom while the rate of output change varied more widely in the United States. In general, a larger fraction of monetary change was absorbed by prices in the United Kingdom than in the United States. We suspect that the pre-World War I stability in the U.K. rates of change may be a statistical artifact rather than a reflection of underlying economic stability.

We regard the rate of change of output as related, first, to real factors, which tend to change only slowly and determine the secular trend, not cyclical or transitory movements, and, second, to deviations of nominal income from its anticipated path, which cause deviations in real growth from the path determined by real factors. We neglect the real factors because, wartime apart, they change slowly.

We derive a relation between the discrepancy between actual and anticipated output growth and, first, unanticipated change in nominal income and, second, a stock adjustment term for the deviation of the level of real output from its equilibrium level. For unanticipated change in nominal income, we substitute unanticipated monetary growth. We interpret the equilibrium level of output as corresponding to long-run potential output and use the ratio of actual to potential output as a proxy for the deviation of the level of real output from its equilibrium level.

We then compare various hypotheses:

1. neglecting vs. including the effect on the rate of change of output of the difference between actual and potential output

2. supposing that economic actors treat both anticipated output and anticipated monetary growth as constants

3. supposing that there are unchanging anticipations for output and adaptive expectations for money

4. supposing that there are adaptive expectations for both output and money.

For the United Kingdom, none of the hypotheses is satisfactory. With initial variability in the rate of growth of real output very low, there is not much variability to account for. For the United States, the assumption of a constant anticipated rate of growth of real output and an adaptive anticipated rate of monetary growth yields a lower residual standard error than any other hypothesis. For this hypothesis the introduction of the stock adjustment term in the form of the ratio of actual to trend output has no appreciable effect on the standard error, though for other hypotheses it perceptibly reduced the standard error.

We also derive the rate of change in real output as a function of current and past rates of change of monetary growth alone by substituting

past monetary growth in the equation for adaptive expectations for both output and money. We have calculated the parameter values for the United States for all nonwar years from such an equation for both nominal income and real output and the implied change in prices. An initially unanticipated rise in monetary growth of one percentage point, maintained at the new level, produces a rise of about 1½ percentage points in the growth rate of nominal income in the initial cyclical phase, of which about one-half a percentage point is offset in the succeeding four phases. For output, an initially unanticipated rise in monetary growth of one percentage point produces a rise of about four-fifths of a percentage point in the initial phase, with subsequent negative values ultimately canceling the initial effect. For the rate of change of prices, the initial effect is about three-fifths of a percentage point, with positive values in phases 2–4 ultimately adding to a sum slightly lower than the percentage point net change in nominal income.

We discuss the implications of our results for the Phillips Curve effect. The simple correlation between a measure of capacity utilization and the rate of price change is the crude empirical basis for the acceptance of a Phillips Curve. The question is whether this result reflects the influence of capacity utilization per se, or whether the level of capacity utilization is serving as a proxy for other variables, particularly the current rate of income growth, itself reflecting monetary growth, and inflationary expectations. Introducing the rate of monetary growth alone as an additional independent variable in the regression of price change on capacity utilization leaves only one of five U.S. correlations, two out of six U.K. correlations, significant at the 0.05 level. As a simple measure of expectations that avoids estimating any additional parameters, we use the rate of price change in the preceding period. Introducing this variable leaves only one out of eleven coefficients significant, and introducing both the rate of monetary growth and past price change leaves two, but both of the significant correlations have the wrong sign. We conclude that insofar as the phase data that are our units of observation are concerned, the Phillips Curve phenomenon is not a major explanatory factor in price change.

Chapters on money and interest rates and on long swings and a summary chapter will complete the manuscript.

Milton Friedman
Anna J. Schwartz

Determinants of Investment

A manuscript, "Factors in Business Investment," has been completed and is now being revised on the basis of comments by staff readers.

The monograph is based on a vast body of individual-firm data derived from McGraw-Hill capital expenditure surveys from 1955 through 1968 and related accounting information. It includes analyses of sales expectations and realizations, inventory investment, capital expenditures, and short- and long-run capital expenditure anticipations. As indicated in previous annual reports, individual chapters focus to a considerable extent on the role of actual and expected changes in sales in affecting the expected profitability and hence the expected rate of business investment. The role of profits is explored, both in itself and in relation to other variables, particularly as it may affect speed of adjustment of capital stock.

The multidimensional nature of the data, involving up to about 500 complete observations distributed in eleven industry groups for each of fourteen years, permits significant analysis of variance and covariance. Various sets of estimates of parameters for different time series and cross sections, by industry and by year and pooled for all industries and all years, are in a number of instances related to differing permanent and transitory components or short-run versus long-run elements in underlying variables.

Robert Eisner

Adjustment Costs and the Theory of Investment

The presence of adjustment costs related to the first derivative of the capital stock for a firm implies a relationship between industry-level investment and aggregate market value of the firms in a competitive industry. This characteristic of adjustment-cost models was described

by Lucas and Prescott *(Econometrica,* September 1971). The implied relationship between these variables has been estimated using pooled quarterly time series of data on U.S. manufacturing industries aggregated to the two-digit level.

The results are much weaker than might be anticipated and indicate that the theory should be modified. More complicated models are being formulated and tested using the data mentioned above.

Peter K. Clark

Macroeconomic Consumption

During my year as research fellow my work on a reformulation of macroeconomic consumption theory has drawn close to completion. Drawing on earlier work on the permanent income theory and on the allocation of transitory income, I developed an integrated model that explains aggregate consumer expenditures as the sum of pure consumption, durables stock change, and the yield on the stock of durables. The primary advantages of an integrated model are that (1) it avoids arbitrary distinctions between durable and nondurable goods and services, and (2) it focuses on the consumer expenditures variable, which is of prime concern to macroeconomists. "Postwar U.S. Consumption, Consumer Expenditures, and Saving," which summarizes the theory and presents preliminary empirical work, was presented at the American Economic Association meetings and published in the May 1975 *American Economic Review.*

The integrated model of consumer expenditures was further elaborated and subjected to a thorough empirical investigation in research reported in "The Consumer Expenditure Function." Because the model relies less on the official classification of commodities as durable or nondurable, it is considerably more effective than multi-equation models in explaining consumer expenditures results. The most surprising finding is that the marginal propensity to spend (excess) real money balances is somewhat larger than the marginal propensity to spend current income for a one-year period. The model performs well when disaggregated according to the official classification of durable goods. Fur-

ther empirical investigation provided strong evidence that (1) private sector (accrued) income is significantly better than disposable personal (cash receipts) income for explaining consumer expenditures, (2) the narrow M_1 definition of money is similarly superior to the broader M_2 and M_3 definitions, and (3) the weight of current income in permanent income is about 10 percent per year. A draft of this paper is circulating for pre-publication comments.

Michael R. Darby

Measurement of Business Inventories

The measurement of inventories and their change has always been one of the most difficult in economic statistics, partly because of the normal difficulties of measuring any stock valued at different prices. Many business firms do not maintain perpetual inventory records but rely instead on periodic (frequently, annual) physical counts and estimated unit valuations to account for inventory costs. The usual problems of inventory measurement have been compounded further in the recent inflation as firms have shifted to alternative valuation methods (notably LIFO) in order to reduce the importance of "inventory profits" and the incidence of income taxes.

Errors in the measurement of inventories in the aggregate have important consequences for the measurement of national income and product and to that extent heighten the danger that businessmen and government may not correctly assess the economic situation and that policy makers may pursue inappropriate cyclical policies. The measurement problem is especially great when the inflation component of current dollar inventory change is large; then, small errors in the current dollar variable and in its price deflator may lead to large errors in the levels and rates of change of the estimated real variable. Similar problems exist in the measurement of sales, orders and related variables.

The need for improving inventory and related data is great. Improvements will better serve the requirements for market analyses by business firms, for use in construction of the national income and product accounts by the Bureau of Economic Analysis, and for analyses and fore-

casts of economic behavior and performance at macro and micro levels by government and private economists. The NBER and the Bureau of the Census, under a joint statistical agreement beginning in April 1975, are undertaking a study designed to assist in that regard and provide a basis for more meaningful and accurate inventory measurement.

Murray Foss
Gary Fromm
Irving Rottenberg

Short-Term Economic Forecasting

Average forecasts from the quarterly ASA/NBER Survey of the Economic Outlook, which was initiated late in 1968, had substantially larger errors in 1973–1974 than in any previous period. They shared in the general deterioration of economic forecasts in these particularly difficult years, reflecting the widespread underestimation of both inflation (which accelerated in an unprecedented way in the last two years) and recession (which was initially disguised by the effects of the energy shortage and later acquired what was to most observers an unexpected severity). Nevertheless, the survey forecasts, which are based on reports from fifty to sixty practitioners in economic forecasting, continued to outperform most purely mechanical methods of autoregressive and other types of extrapolation.

The additional evidence for recent forecasts confirms earlier findings that no particular technique or source of forecasts is systematically superior to others, that is, best consistently over time or best for all the variables covered. For example, the median ASA/NBER forecasts have recently been less accurate than most of the forecasts with econometric models with regard to GNP and expenditures on consumer durables but more accurate than most with regard to the unemployment rate and inventory investment. Their relative accuracy was also often higher over the shortest spans (of one and two quarters) than over the longer spans (of three and four quarters). Similarly, forecasts for a given future period tend to be better the later they are made. Thus, the median predictions of GNP and the price level for the year ahead from the November ASA/NBER surveys in 1969–1974 had somewhat larger average errors than the corresponding predictions from the January *Economic Report of the President* (Council of Economic Advisers), while the predictions from the February surveys had somewhat smaller errors.

The forecasts from the surveys conducted by the American Statistical Association are analyzed and interpreted on a current basis at the National Bureau by Charlotte Boschan and myself. Several publications which have appeared recently or are in preparation have been drawn upon above: Geoffrey H. Moore, "Economic Forecasting—How Good a Track Record?" *Morgan Guaranty Survey,* January 1975; Vincent Su and Josephine Su, "An Evaluation of ASA/NBER Business Outlook Survey Forecasts" (a proposed paper for NBER *Explorations in Economic Research*); Victor Zarnowitz, "The ASA/NBER Forecasters' Panel Looks at 1975," *Economic Outlook USA* 2, no. 1. For an "outside" assessment of several econometric-model and the ASA/NBER forecasts, see Stephen K. McNees, "How Accurate Are Economic Forecasts?" *New England Economic Review,* November/December 1974.

Victor Zarnowitz

Evaluating Forecasting Performance of Econometric Models

This project, supported by a grant from the National Science Foundation, aims at collecting and analyzing the forecasting performance of four quarterly models of the U.S. economy—the BEA, Wharton, Michigan, and Fair models. The compilation of the ex-ante forecast record together with the model equations and assumptions used to produce it will constitute a basic resource for further analytical work.

Preliminary analysis will include the presentation of the record of forecasts for each model, the turning point accuracy of the forecasts, and comparisons with other ex-ante forecasts and with forecasts from standard "naive" models. In addition, a record of data revisions will be compiled, continuing and extending the work of Roseanne Cole (*Errors in Provisional Estimates of Gross National Product,* New York, National Bureau of Economic Research, 1969), and ana-

lyzing their effect on econometric forecasts.

There are two basic thrusts to the analytical work on error decomposition. The first involves a rigorous examination of the distribution of forecasts from a nonlinear (in the dependent variables) model to derive the covariance matrix of the forecast errors. The second involves attempting to separate the mean square error of forecast obtained from the historical records of the forecasts of each model into components attributable to (1) the irreducible uncertainty arising from absence of knowledge of the parameters (this is the point of obtaining the distribution of forecasts), (2) the lack of exact information on the exogenous variables, (3) revisions in data, and (4) constant adjustments (if any). This will leave a residual component that may be taken to reflect structural change and/or misspecification or aggregation errors.

It is hoped that the results of this decomposition will help model builders in revising appropriate parts of their models or the techniques by which they estimate them.

Phoebus J. Dhrymes
Victor Zarnowitz

Seasonal Analysis of Economic Time Series

Both from practical and theoretical points of view, it is important that existing methods for analyzing seasonal components of economic time series be improved. Economic forecasters and policy analysts, concerned with short-run movements of the economy, must account for seasonal variations because they comprise large portions of the fluctuations in many important economic variables. Also, there is growing interest in providing better theoretical understanding of the sources and nature of seasonal variation in economic time series.

The Bureau of the Census has recognized these needs and is sponsoring an NBER/CENSUS Conference on Seasonal Analysis of Economic Time Series, which is scheduled to be held in Washington, D.C., in spring 1976. A two-day meeting is planned at which papers will be presented and discussed; the proceedings of the conferences are to be published.

The Steering Committee for the Conference held its initial meeting in January 1975 and selected subject areas to be announced in the call for papers. Possible topics are: comparison of different methods of seasonal adjustment, criteria and procedures for evaluation of methods of seasonal analysis and adjustment, seasonality and econometric modeling, statistical inference and seasonal analysis, seasonal analysis and forecasting, treatment of special problems (such as trading-day adjustments, holiday adjustments, combining seasonally adjusted series, conversion of data to lower frequencies, extrapolation of seasonal factors, aggregation and seasonal analysis, and others), and reporting of seasonal analyses.

It is anticipated that the Steering Committee will select about twelve papers for presentation to the Conference. Announcement of the papers to be included in the Conference program was made in summer 1975. Papers selected for presentation to the Conference must be completed and sent to discussants by December 15, 1975. Final publication of papers in the Proceedings volume is subject to approval by the Steering Committee. Membership of the Steering Committee is as follows: Arnold Zellner (Chairman), University of Chicago; William S. Cleveland, Bell Laboratories; Robert F. Engle, MIT; A. L. Finkner, Bureau of the Census; Gary Fromm, National Bureau of Economic Research; W. Bruce Gabbitas, E. I. Du Pont de Nemours and Company; C. J. W. Granger, University of California; E. Philip Howrey, University of Michigan; Shirley Kallek, Bureau of the Census; Michael C. Lovell, Wesleyan University; Charles R. Nelson, University of Chicago; Julius Shiskin, Bureau of Labor Statistics; Max Shor, Bureau of the Census; George C. Tiao, University of Wisconsin; and Donald G. Watts, Queen's University.

Gary Fromm
Arnold Zellner

Public Finance

Model for Evaluating Alternative Federal Policies

The public finance research program is grounded in the recognition that large-scale changes in public policy instruments must be evaluated in closed, differential incidence terms

—i.e., that the consequences of a fully specified menu of policy change must be explored within a framework that incorporates both direct effects and indirect behavioral responses. Thus, the essential thrust of this research program has been the development of a closed-system policy analysis capability.

This capability was greatly extended by the development of IDIOM (Income Determination Input-Output Model), a prototype interindustry, national-regional model designed to identify the consequences of basic changes in fiscal structure at a highly disaggregated level—e.g., by region, by industry and by occupation.[1] IDIOM has become a particularly useful tool and has constituted the core of our continuing research program. It provides a skeletal structure on which a developmental research effort can be based while simultaneously permitting concrete analyses of current policy options to be carried out. This dual capability was a conscious objective in the evolution of the model and has been fully exploited in the progress of our research over the past year.

The primary tasks planned for the current year involved fundamental extensions of the model's capabilities, especially the endogenous incorporation of price and wage adjustments, of investment, of international trade and interregional migration, the more explicit representation of the household sector, and the development of an environmental policy capability. In addition, we intend to devote a reasonable fraction of our resources to disseminating the existing model and applying it to the analysis of current policy issues, with an elaboration of the compensating policy substitutions framework embodied in the model to permit a wider range of policies to be explored.

What we did not anticipate, however, was the succession of major economic "crises" that has characterized the past eighteen months. The consequence of these unexpected topical concerns was a much greater allocation of resources to applying the existing model and to modifying it to permit us to address a succes-

sion of immediate policy issues.[2] Only on the basis of our earlier model development efforts were we able to contribute significantly to the explanation of real policy options in a rapidly changing national and international economic environment.

The most far-reaching of our topical analyses has been in the area of energy policy. With the "sudden" emergence of the energy crisis in the fall of 1973, the model was quickly adapted to permit the analysis of alternative energy policies, specifically including special excise taxes, energy rationing, and energy allocation programs. With the development of "Operation Independence," the model has been further adapted to permit estimates of future energy needs under alternative policies, of investment programs required to meet these needs, and of the pervasive economic impacts of alternative degrees of, and approaches to, energy independence.

This work has been carried on in close cooperation with the Systems Analysis Group of the Bureau of Competitive Assessment and Business Policy, U.S. Department of Commerce. We have developed a variant of the model for use on a direct-access, time-sharing basis by the Systems Analysis Group. Significant efforts have been devoted to modifying the model to meet the needs of the Group, and IDIOM has become a central component of their analysis capabilities in the area of energy policy, especially in the regional and interindustry dimensions.

Although this aspect of our effort has absorbed a much greater share of our resources than originally planned, major progress has been made in the development of a more completely articulated general equilibrium policy analysis capability. The design phase of this effort has been completed and progress has been made toward its empirical implementation.[3]

This research has been supported primarily

1. Stephen P. Dresch and Robert D. Goldberg, "IDIOM: An Interindustry, National-Regional Policy Evaluation Model," *Annals of Economic and Social Measurement* 2, No. 3, July 1973.

2. See, for example, Stephen P. Dresch, "Economic Stabilization and the Composition of the Federal Budget," August 30, 1974, prepared for the White House Conference on Inflation.

3. This facet of the research is described in two papers: An-loh Lin, "A Multiregional, Interindustry, General Equilibrium Model of Prices and Outputs"; and An-loh Lin and Wu-lang Lee, "An Application to the U.S. Economy," 1974.

Stephen P. Dresch
An-loh Lin
Robert D. Goldberg
Wu-lang Lee

2. URBAN, REGIONAL, AND ENVIRONMENTAL STUDIES

Urban Studies

Introduction

The NBER urban and regional studies group has
shifted more heavily during the past year toward
efforts to improve the NBER Urban Simulation
Model and to use the improved model to analyze
housing programs and policies. To a substan-
tial extent this reorientation reflects the comple-
tion or near completion of several large econ-
ometric studies of urban housing markets and
industry location. Mahlon Straszheim's study
of the San Francisco-Oakland metropolitan
housing market, *An Econometric Analysis of
the Urban Housing Market*, was published in
May and John F. Kain and John M. Quigley's
study of the St. Louis housing market, *Housing
Markets and Racial Discrimination: A Micro-
economic Analysis,* is scheduled to appear in
the fall. In addition, John M. Quigley has nearly
completed his study of the Pittsburgh housing
market and expects to submit it for staff and
board review early this year. A paper from this
study, "Housing Demand in the Short Run: An
Analysis of Polytomous Choice," is scheduled
for publication in the Bureau's new journal, *Ex-
plorations in Economic Research*.

The major part of our research during the
past year, however, has been under our con-
tract with the Department of Housing and Urban
Development. In November 1972 we received
a two-year contract from the Department of
Housing and Urban Development to further
develop the NBER Urban Simulation Model and
to use it to analyze housing abandonment. Then
in June 1974 HUD asked us to redirect our
model development and support research ac-
tivities toward an evaluation of the impact of
housing allowances on urban housing markets
and provided additional funding and a one-year
extension of the contract.

The challenge provided us by HUD was a sub-

stantial one and it is still too early to evaluate
how well we will succeed. HUD is anxious for
us to complete model development and to com-
plete program simulations using the full model
as soon as possible. At the same time they were
very anxious to obtain as much analysis as pos-
sible for use in their fall 1974 internal review of
housing allowance programs. As a result we
agreed (1) to proceed with the improvements
and extensions of the Bureau model to make it
suitable for the evaluation of allowance pro-
grams, and (2) to provide interim analyses of
housing allowance programs based on our pre-
vious and continuing research on urban housing
markets. These interim analyses were presented
to HUD in a series of informal working papers in
the fall and in an interim report submitted to HUD
in December 1974.[1] The individual progress re-
ports that follow discuss both this report and the
continuing progress in model development.

<div align="right">John F. Kain</div>

Programming the NBER Model

Under our current HUD contract we are obli-
gated to calibrate an improved version of the
NBER Urban Simulation Model to Pittsburgh
and Chicago and to use these models to simu-
late the market effects of allowance programs.
We refer to the Pittsburgh version of the model
as Pittsburgh II. The Pittsburgh II version of the
NBER Urban Simulation Model will employ a fun-
damentally different method of data storage and
processing than earlier versions of the NBER
model. Specifically, Pittsburgh II stores house-
hold and housing unit data as individual sample
observations rather than as the elements of large
matrices of characteristics. This fundamental

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1. John F. Kain, ed., *Progress Report on the Development
of the NBER Urban Simulation Model and Interim Analysis
of Housing Allowance Programs* (New York, National Bu-
reau of Economic Research, December 1974).

change in our approach to data storage and processing and the reasons behind the change are discussed in two reports to the Department of Housing and Urban Development.[2]

The approach to data storage and processing that we will use for Pittsburgh II has many advantages over that employed in earlier versions of the model and has long been used for smaller and less complex simulation models. Until recently, however, its use in a computer simulation model as large, complex, and disaggregate as the NBER model would have been prohibitively expensive. Recent improvements in disc storage and in particular the widespread availability of the 3,330 disc device have markedly changed the nature of these tradeoffs and have allowed us to adopt this method of data storage and processing for the Bureau model.

One consequence of the decision to fundamentally change the method of storing and processing data in the Bureau model was that the model's computer program had to be completely redesigned and reprogrammed. Since there remain a number of major questions about the design and calibration of the supply sector of Pittsburgh II, we began redesigning and reprogramming the demand and market-clearing sectors of the model. In addition to reprogramming the movers, vacancy, demand, and market-clearing submodels adapted from earlier versions of the Bureau model, we had to design and program a number of entirely new submodels for Pittsburgh II. For the demand sector these include a job choice and retirement submodel and a tenure choice submodel.

Initial programming of the demand and market-clearing sectors of Pittsburgh II have been completed and we have been using test data to debug these portions of the model. Over the next few months we plan to devise a number of increasingly complex analyses for the demand and market-clearing sectors. These partial analyses will help us identify further bugs, assist in calibrating these sectors, and increase our understanding of the model's properties. We anticipate that lessons learned from these experiments will lead us to redesign and reprogram portions of the demand and market-clearing sectors. During 1975 we expect to complete these partial tests of the demand and market-clearing sectors of the model, to complete the design and programming changes they suggest, and to make significant progress in programming the supply sector of the model. Toward the end of the year we plan to carry out a number of program simulations with the entire model.

<div align="right">J. Royce Ginn
H. James Brown</div>

Demand Analysis and Housing Allowances

Before a final analysis of housing allowances could be undertaken, we felt that it was essential to review thoroughly and to extend our work on housing demand. Of crucial concern are estimates of the income and gross price elasticities of demand for individual housing attributes and bundles. We continue to believe that the multinomial logit model is the most promising technique to estimate these crucial demand equations and we have used Pittsburgh data to experiment with different stratifications of family types and different specifications of the logit equation. In addition, we are currently reestimating these demand equations for Chicago and San Francisco.

To assist the Department of Housing and Urban Development in its fall 1974 internal evaluation of housing allowance programs, we adapted the submarket demand equations and other portions of the demand and market clearing sectors of the NBER Urban Simulation Model to carry out partial analyses of allowance programs.[1] Specifically, we devised and used the Housing Allowance Demand Simulator (HADS) to evaluate the effects of housing allowance

2. John F. Kain, William C. Apgar, Jr., J. Royce Ginn, and Gregory K. Ingram, "First Report on Contract to Improve the NBER Urban Simulation Model and to Use the Improved Model to Analyze Housing Market Dynamics and Abandonment," (New York, National Bureau of Economic Research, June 1973, processed) and J. Royce Ginn, William C. Apgar, Jr., H. James Brown, and John F. Kain, "Progress in Model Development," in John F. Kain, ed., *Progress Report on the Development of the NBER Urban Simulation Model and Interim Analyses of Housing Allowance Programs* (New York, National Bureau of Economic Research, December 1974, processed).

1. William C. Apgar, Jr., and John F. Kain, "Effects of a Housing Allowance in the Pittsburgh Housing Market," in John F. Kain, ed., *Progress Report on the Development of the NBER Urban Simulation Model and Interim Analyses of Housing Programs* (New York, National Bureau of Economic Research, December 1974, processed).

programs of different sizes and types on the demand for specific housing attributes and bundles. Our program simulation experiments with HADS provided some preliminary estimates of the probable range of quantity and price effects that would result from a housing allowance.

Most analyses of the likely effects of a housing allowance program treat housing as a homogeneous good and consider the effects of the allowance on housing expenditures and prices. As in the NBER model, the HADS model uses separate demand equations for 264 types of households defined in terms of the race, age, and employment status of the head of household and family size and family income to predict demand for 90 distinct housing types of bundles. This procedure allows us to consider the effects of these socio-economic demographic characteristics on the demand for individual housing attributes and bundles.

Although we have always been convinced that housing demand could best be represented as the consumption of distinct bundles by diverse household types, HADS provided the first practical demonstration of the importance of this disaggregated view for policy analysis. Whereas more conventional analyses stress the likelihood of massive allowance-induced price increases, HADS indicated that steep declines in the price of some less desirable types of housing and perhaps widespread abandonment may well be a greater problem. This result reflects the finding that program-induced increases in demand would be dispersed among a fairly large number of housing bundles in medium- and high-quality neighborhoods, while program-induced decreases in demand would be concentrated in a few types of housing located in the least desirable neighborhoods.

Although the results of the HADS analysis is interesting in and of itself, it also further underscores the potential usefulness of the NBER Urban Simulation Model. The degree of disaggregation and complexity has slowed its development, but the HADS experiment demonstrates the model's capability for providing rich and detailed policy analysis.

William C. Apgar, Jr.
John F. Kain

Residence Choices of Multiple Worker and Elderly Households

The NBER Urban Simulation Model considers the specific workplace of employed households in determining the housing bundle and residential location choices of modeled households. Since our analysis of the Pittsburgh home interview survey revealed that slightly more than one-quarter of all households have more than one worker, we felt that we should attempt to determine whether there were any differences in the housing choices of single- and multiple-worker households. Therefore, during the past year we initiated research to evaluate whether the workplace location of other members of the household affected these decisions.

Our analysis of residence selection of two worker households proceeded along two lines. First, we used the multinomial logit technique to estimate housing demand functions for two-worker households and compared the coefficients from these two-worker equations with those obtained for single-worker households. Second, we compared the length of worktrips by members of single- and multiple-worker households choosing the same housing bundles. Preliminary results do not reveal any systematic differences in housing demand or worktrips between single- and multiple-worker households. To the extent that these results are supported by further tests, it appears that the failure to consider the specific workplaces of secondary workers may not have serious consequences.

We expect, in the next few months, to complete these comparisons and to prepare a paper detailing the analysis.

Because of the importance of elderly households in any housing allowance program, we undertook a separate empirical analysis of the moving behavior and housing choices of elderly households using a special retrospective survey by the Bay Area Transportation Study Commission.

The first striking characteristic of elderly households is their low mobility rates. Only 11 percent of elderly renters move annually, as compared to 29 percent of other renters. Similarly, only 2 percent of elderly owners as compared to 5 percent of other owners move an-

nually. Furthermore, nearly 3 percent of elderly owners with incomes less than $5,000 move, whereas only about 1.5 percent with higher incomes change their residence. The opposite result holds for renters. Almost one-quarter of the highest income households relocated as compared to one-tenth of the lowest income households.

It is widely believed that many elderly low-income homeowners are "forced" to move by rising taxes and maintenance costs. The fact that the lowest income elderly homeowners have the highest moving rates of all elderly homeowners provides some support for this position. At the same time, the annual moving rate for low-income owners is very low. Less than 3 percent of low-income owners move annually whereas renters in the same income class move roughly four times as often. Thus, the data do not indicate that large numbers of elderly low-income owners are being "forced out" of their homes by declining incomes and rising costs.

Somewhat surprisingly, we were not able to show that elderly households showed any tendency to move more often from either larger residences or from single-family units. The elderly do have a higher tendency to choose their new residences in smaller and multiple-family units. Thus, as expected, the net result of the movement of the elderly in the housing market is to make vacant larger and single-family units.

Finally, there was some evidence that elderly households make shorter moves than other households. Although this evidence is far from certain and the sample is too small for formal testing, it is consistent with the view that the elderly do have stronger attachments to their previous neighborhoods than do other homeowners and renters.

H. James Brown

The Supply Side of the Housing Market

The supply side of the housing market has been represented in earlier versions of the NBER model in a reduced-form manner that has become less satisfactory as other portions of the model have improved. We have, therefore, begun to design and specify a richer and more structural representation of housing supply ac-

tivity for incorporation in Pittsburgh II.

In this representation, we assume that the abilities of housing suppliers to produce various housing attributes that households demand are different. Some attributes, such as dwelling-unit quality, are produced by operating inputs and fairly short-lived capital; housing suppliers can alter the level of these attributes over short periods so that their supply is fairly elastic. Other attributes, such as structure type, are produced by very long-lived capital; housing suppliers can alter these attributes but their long life means that future expectations play a large role in supply responses. Finally, still other housing attributes, such as neighborhood quality, are not produced directly by housing suppliers at all, yet changes in them may affect demand; and expectations about these attributes may be significant determinants of other supply activities.

A simple model of the supply of dwelling-unit quality has been crudely calibrated and used to make conditional predictions about the magnitude of short-run price increases that would occur if demands for dwelling-unit quality suddenly increased.[1] This model is currently being extended to include structure type and neighborhood quality. A modification of this model will be developed for inclusion in the NBER Urban Simulation Model during the next few months.

Gregory K. Ingram
Yitzhak Oron

Owners of Rental Property

A better understanding of how owners and managers operate rental housing is essential to an evaluation of recent housing policy proposals, such as the housing allowance program. In particular, we must be able to predict how the operating, maintenance, and capital improvements of owners and managers of rental property are affected by real or perceived changes in housing market conditions. Unfortunately, housing market analysts lack an adequate un-

1. Gregory K. Ingram and Yitzhak Oron, "Stand-alone Supply Model for Dwelling Unit Quality," Section IV in John F. Kain, ed., *Progress Report on the Development of the NBER Urban Simulation Model and Interim Analyses of Housing Programs* (New York: National Bureau of Economic Research, December 1974, processed).

derstanding of the decision-making processes of the owners and managers of rental housing and there is very little systematic data on these processes. In an effort to remedy this situation, we interviewed housing suppliers in three Pittsburgh and ten Chicago neighborhoods. The sample neighborhoods in each city were selected in terms of housing density, housing quality, and the pattern of prices over the 1960–1970 period to facilitate analysis of landlord behavior under different market conditions. We obtained systematic data on the maintenance and investment histories of particular parcels including an income statement for each of the last five years and a complete investment history. This information will allow us to determine whether the costs of producing housing vary by neighborhood.

From the start we realized that the task was a very difficult one; it is not easy to extract this type of information from landlords. Initially we planned 100 interviews in Pittsburgh and 400 in Chicago. NBER conducted the interviews in Pittsburgh and the National Opinion Research Center conducted the Chicago interviews. In both cases, it has been necessary to reduce the sample size because of the difficulty and cost of interviewing. Pittsburgh is complete with 60 responses, and Chicago is just finishing up with 200. We are now preparing the data for analysis.

Preliminary analysis of the Pittsburgh data suggests that landlords do not make many changes in their maintenance and operating policies; nearly all the responses indicate that there were no changes in these policies during the last five years. This limited initial analysis also indicates that profitability and maintenance policies vary with the type of landlord. Other studies have pointed to the importance of the owner's presence as a resident of the building. In addition, professional owners, professional managers, and several types of part-time owners operate differently. These differences can be understood in terms of the different objectives of the various landlords. Professional owners maximize profits and understand the capitalization of net income. Professional managers are similar except that they try to hide the true value of the parcel from the owner (who is usually small and does not understand capital-

ization) because of the possibility that the firm may wish to buy the property. Small owners have a more varied set of objectives; some may value being considered a friend by their tenants; others may be satisfied to live rent free; others place a high value on having tenants who will be good neighbors or become attached to the property and take pride in its appearance. On the other hand, some appear to have objectives similar to the professional owners.

Early analysis of the Pittsburgh data also indicate that there is a considerable amount of variation in landlord behavior among neighborhoods, which is not susceptible to some simple explanation. For example, one might expect capital expenditures to be less in the declining neighborhoods. Still, preliminary analysis reveals that some landlords in declining neighborhoods make capital expenditures that are as large or larger than those made by landlords in better neighborhoods.

This brief sketch serves to highlight some of the challenges that remain for the complete analysis. If the neighborhood variation and the role of landlord types proves to be important, the modeling task will be more difficult. We remain optimistic, however, that certain basic patterns of landlord behavior will emerge and that this data will allow us to calibrate a supply submodel for Pittsburgh.

Robert Schafer

Mobility of Household's Residences and Workplaces

I have completed a preliminary draft of a paper concerned with the mobility of urban households. In the model used in my study, the two intraurban mobility decisions, whether the household moves its residence and whether it moves its workplace, are simultaneously determined in a utility maximizing framework. This assumption differs from the assumption made by the researchers developing the NBER Urban Simulation Model. For the purpose of facilitating simulation, the authors of that study, *The Detroit Prototype of the NBER Urban Simulation Model,* assumed that white households adjust their residence location relative to a fixed workplace. One of the major purposes of my study is to

test the tenability of that hypothesis.

I have investigated the effects of both economic and sociological factors on mobility. The determinants of residential mobility include workplace mobility; life-cycle characteristics such as age, sex of head of household, and family size; changes in family size and composition; race; prior tenure; income; education of household head; the number of workers; neighborhood quality; transportation costs; housing market conditions; public goods and services; taxes; past mobility; and housing prices. The determinants of the household head's workplace mobility include residential mobility, life-cycle characteristics such as age and sex, education, race, transportation costs, labor market conditions, occupation, and the number of workers in the family.

Information is available on the mobility behavior of households over a ten-year period for the San Francisco Bay Area from a home interview survey conducted in 1965 by the Bay Area Transportation Study Commission. This survey provides ten-year residential, employment, and personal histories for each sampled household. Several interesting econometric problems are associated with estimating the mobility model, problems associated with dichotomous dependent variables, simultaneous equations, and pooling of a time series of cross sections.

The bulk of the model estimation has been completed. The remaining work involves exploring alternate estimation techniques and revising the preliminary draft. No immediate publication is planned. This project is financed with NBER funds.

<div style="text-align: right">Daniel H. Weinberg</div>

Workplace Location

Since 1970 the Bureau has undertaken several workplace location studies using various sources of data on employment and workplace changes. Of particular value in these undertakings, because of their micro detail, have been Dun & Bradstreet establishment data. In the past year, Warren Lavey completed a study now available in the NBER Working Paper Series (No. 52) entitled "Transportation/Communication Considerations in the Location of Head-

quarters for Multi-Establishment Manufacturing Firms." This study, which is a direct outgrowth of earlier NBER efforts, utilized a rather unique "combinatorial" approach to the problem of testing alternative hypotheses. By literally counting the number of patterns of location behavior, Lavey tested several hypotheses regarding the spatial linkages among the component establishments of multiplant firms.

Robert A. Leone and Raymond Struyk completed a paper entitled "The Incubator Hypothesis: Evidence from Five Cities," which is also available in the NBER Working Paper Series (No. 45). Synthesizing the results of past NBER workplace studies, this paper demonstrated that the concept that high-density central city areas serve as "incubators" of new business activities that later grow and relocate in lower-density areas has little empirical support, at least in the case of manufacturing industries.

Prior research had indicated that the issue of plant closings and their geographic distribution is among the most intriguing and least empirically understood of the changes in the pattern of workplace location. As part of the research undertaking for the National Commission on Water Quality, NBER has developed a small data base on some 400 industrial closings since 1967. These data will make it possible to document at the plant level recent changes in establishment "death" rates according to facility, firm, and location characteristics.

<div style="text-align: right">Robert A. Leone</div>

Regional and Environmental Studies

An Analysis of Federal Economic Development Programs

The overall purpose of this project is to review the EDA experience in both historic and economic perspective and to apply any lessons learned to the future course of regional development policy. To achieve this purpose, our research was divided into four stages.

We have essentially completed the historical perspective phase of our study. We have reviewed the intellectual and legislative history of EDA and will analyze what was done by EDA

and how successful it was. To accomplish that objective, we detailed what the agency did in terms of its legislative mandate. Changing policies and patterns of implementation were documented with special emphasis on the evolution of policy as new lessons were learned.

An essential element of the study is the development of a perspective on the economic effect of EDA. A general economic analysis is under way to determine whether EDA had a statistically discernible effect on the level of aggregate economic activity in the communities in which it operated and on the "target" populations in them. An analysis of the industrial content of EDA action is also contemplated.

Our final research objective is to identify and evaluate future regional development strategies. This examination will rely on two inputs: the lessons gained from the retrospective review of past policies and an enumeration of those emerging national goals that will affect regional development policy. One paper in this objective, "The Urban Disamenity Revisited," by John R. Meyer and Robert Leone, is part of an effort to document the costs of urbanization and economic growth. Other papers prepared for this project during the past year include "Resource Constraints to Regional Economic Development" by James Smith, "Demographic Trends and EDA Development Policy" by Charles Mueller, "EDA Legislative History Before 1965" and "EDA Legislative History 1965–1974" by Curt Martin, and "Preliminary View of the Incidence and Impact of Recent Regional Development Programs" by James Freund.

This project is financed with a grant from the Economic Development Administration, U.S. Department of Commerce.

Edward K. Smith
Robert A. Leone

Water Quality

In a study supported by the National Commission on Water Quality, members of the Bureau staff have been exploring the industrial impact of federal water pollution control legislation on six industries: petroleum, pulp and paper, iron and steel, nonferrous metals, textiles, and electroplating. Preliminary findings indicate that "im-

pacts" can be broadly segregated into two categories: those that occur at the industry level and those most significant at the plant level.

On the industry level, the research team is examining the near-term effects of water pollution controls on production costs, prices, and output levels. Preliminary findings indicate that the imposition of pollution controls can lead to short-term capacity constraints that, in turn, can lead to price increases in excess of any direct cost increases associated with the controls. This impact is particularly noticeable during periods of high capacity utilization, which implies that the timing of controls with respect to the state of the business cycle is an important determinant of "impact."

In the long run, changes in an industry's cost structure caused by the pollution legislation may have significant market effects not so readily observable as the direct price effects that receive so much public attention. In some cases, for example, the economies of scale of waste water treatment could create serious barriers to entry into an industry, and thus might contribute to a basic change in an industry's competitive structure.

At the plant level, the researchers are attempting to demonstrate that most efforts to measure the "cost" of water pollution control are "upper-bound" estimates, since they typically do not consider opportunities to recycle water, potential water-conserving technologies, and possible changes in product mix and product specifications.

This project, under the direction of J. Royce Ginn of the senior research staff and Robert A. Leone, Research Associate, is expected to be concluded during the fall of 1975.

Robert A. Leone

Air Pollution and Health

This study investigates the health effects of air pollution in the Washington, D.C. metropolitan area. It is being funded jointly by the Environmental Protection Agency and the Department of Transportation.

To date, only a limited number of studies have analyzed the health effects of air pollution generated by motor vehicles. Estimates of health

and economic impacts in these studies generally have been based on extrapolations from the consequences of air pollution in very specific instances. The unique feature of the current study is the direct measurement of mobile-source air pollution effects on health, medical treatment expenditures, and work days lost. Washington was selected because mobile-source pollution is a dominant factor in the area, whereas stationary sources (e.g., industrial plants) are the chief causes of pollution in other major eastern seaboard cities.

If data are available, the distributional effects of health-related air pollution damages will also be analyzed. In addition, if data permit, an examination of the effects of commuting behavior in terms of the implications on the health of commuters will be made. The results should be useful in assessing the potential benefits of antipollution policies associated with the automobile and in evaluating the health-related aspects of various transportation strategies.

Preliminary results of this research were presented at the Western Economic Association meetings in June 1975.

<div align="right">Eugene P. Seskin</div>

Uses of Energy and Resources

We have been examining approaches to analyzing the demand for energy. A group of researchers met in July to discuss areas of mutual interest and possible cooperation in the fields of energy and resource use. It was agreed that we would cooperate on a program to measure various aspects of energy demand.

Robert Halvorsen is examining the characteristics of industrial demand for coal, oil, gas, and electric energy. The results of the study will include estimates of demand and elasticities of substitution of energy inputs as well as of changing technological efficiencies. Transcendental logarithmic cost functions are being used to derive complete systems of demand equations for energy inputs.

Other research efforts are exploring models of other methods of estimating demand. The rapid increase in the costs of energy affects the relative efficiency of the use of energy in comparison to other inputs. These in turn lead to relative price changes. These are the impacts we hope to measure.

<div align="right">Sherman J. Maisel</div>

3. HUMAN BEHAVIOR AND SOCIAL INSTITUTIONS

Introduction

In its third year of operation, the NBER's Center for Economic Analysis of Human Behavior and Social Institutions continues to focus on four main areas: income distribution and education, law, health, and population.

The Center's research emphasizes the interrelationship between economic decisions in the "non-market" sector regarding marriage, fertility, health, etc., and behavior in markets of traditional economic concern, such as those for labor, capital, and goods and services. The determination of labor force size, composition, and productivity; of levels and rates of change of earnings; and of the demand for schooling, medical care, and legal services are all topics currently under study. Our understanding of these phenomena is enhanced by an analysis of the non-market activities of households. Conversely, the non-market behavior that is of in-

creasing social concern is better understood by the analysis of changes in factor and product markets.

Regarding the Center's future research, we are actively considering projects dealing with (1) the role of the family as a social institution and as a frame of reference for decisions regarding health care, training, fertility, and labor supply; (2) certain public policy decisions regarding taxation and the public provision or subsidization of services; and (3) the appropriate use of recently available longitudinal data sets in studying sequential decision-making regarding family formation, training, and working.

The research output of the Center during the past year includes six new NBER volumes, about twenty NBER working papers, and numerous published articles in NBER journals, as well as in other professional journals and conference

volumes. The research of the Center is supported by funds from several private foundations including the Rockefeller Foundation, the Robert Wood Johnson Foundation, the Ford Foundation, and the American Bar Foundation; by funds from several agencies of the federal government, including the National Science Foundation, the National Institute of Child Health and Human Development, the National Center for Health Services Research, and the U.S. Department of Labor; as well as by funds of the National Bureau.

The administrative office of the Center is located at NBER-West in Palo Alto, California. The administrative officers of the Center are: Victor R. Fuchs, Director; Robert T. Michael, Associate Director; Gary S. Becker, Research Policy Advisor; and Frances Selhorst, Business Manager. The Program Directors of the Center's four program areas introduce the staff reports that follow.

<div align="right">Victor R. Fuchs
Robert T. Michael</div>

Income Distribution and Education

Introduction

The major research emphasis of the Center's program on income distribution and education is the analysis of the determinants of individuals' lifetime earnings, using longitudinal data. Most of the evidence currently available on the relationships among schooling, job training, and earnings is obtained from cross-sectional data. Information on an individual's behavior and earnings over several sequential years offers an opportunity to investigate far more precisely the interrelationships among a whole set of historical and contemporary factors affecting hourly earnings and labor supply.

The factors currently being investigated include family background, measured ability, formal schooling, aging, marital and fertility histories, job training, and job mobility. Some of the research approaches the topic in the context of quite formal models of optimal lifetime plans for the allocation of time and money to learning, earning, and consuming. Other studies identify econometrically the partial relationships

among certain aspects of prior behavior and current earnings and labor supply. All of these studies utilize a human capital analytical framework, but they differ substantially, for example, in how they deal with the individual's objective function, the nature of the human capital production function and its output, and the nature of vintage or cohort effects.

The Coleman-Rossi continuous work history data, the four samples from the National Longitudinal Surveys, the University of Michigan's Income Dynamics five-year panel survey, the NBER-Thorndike-Hagen sample, and the National Science Foundation's National Registry of Technical and Scientific Personnel are currently being used extensively in this research effort. The reports below by Jacob Mincer, Ann Bartel, Lee Lillard, Yoram Weiss, and James Heckman summarize much of this research.

Several additional studies complement this research on longitudinal earnings data. James Smith and Finis Welch report on changes during the 1960s in earnings differentials between blacks and whites; Victor Fuchs has studied changes during the 1960s in earnings differentials by sex and has recently completed a study of changes in sex segregation in professional occupations during the 1950s and 1960s that was published in the winter 1975 issue (Vol. 1, No. 2) of the NBER journal *Explorations in Economic Research*. Another complementary study is Isaac Ehrlich's analysis of the determinants of the mix between human and nonhuman lifetime wealth accumulation. Similarly, the studies reported below by Kenneth Wolpin, Edward Lazear, and Kathleen McNally add to our understanding of the determinants of levels of schooling.

Two more exploratory studies are also reported below. Michael Boskin reports on his recent studies of public finance aspects of human capital accumulation, and Robert Michael reports on his study of a quite different aspect of the distribution of real income—differential rates of inflation across households.

During the past year the NBER published five books related to our income distribution and education research program. These volumes were: Barry R. Chiswick's *Income Inequality* (December 1974); Paul Taubman and Terence Wales' *Higher Education and Earnings* (Decem-

ber 1974); F. Thomas Juster, ed., *Education, Income, and Human Behavior* (January 1975); Gilbert R. Ghez and Gary S. Becker's *The Allocation of Time and Goods over the Life Cycle* (May 1975); and the second and expanded edition of Gary S. Becker's *Human Capital* (July 1975). Essays by Lewis C. Solmon and Paul Wachtel are to appear in *Explorations in Economic Research* and an essay by John Hause has been submitted to the *Annals of Economic and Social Measurement*. More than a half dozen NBER working papers from this research group have appeared within the past year.

Lee A. Lillard
Robert T. Michael

Work Experience and the Distribution of Earnings

During the past year we have been engaged in a full-scale analysis of longitudinal microdata sets containing information on individuals' work and (some) earnings histories. Our purpose is to deepen our understanding of the determinants of earnings and of earnings distribution with information not usually available in cross sections.

In particular:

1. We replaced total work experience of men, previously (e.g., in my 1974 NBER monograph) measured as time elapsed since completion of schooling, by a detailed work history of each man. This was done, in association with George Borjas, for the NLS sample of men who were 45–59 years old in 1966, using their 1966 retrospective data and the 1966–1969 panel. The same analysis was applied to data on young men who were 14–24 in the initial survey and to their three-year panel.

As a basic step forward from the cross-section analysis, this work provides insights into individual differences in post-school human capital investments that take the form of inter-firm job mobility and intrafirm job (wage) progress.

Some of the findings are:

a. A positive correlation between job duration and wage growth works out to the advantage of men who are less mobile in their last two decades of work, despite the fact that voluntary mobility (quits) induces wage gains. Evidently, effects of job training accumulation dominate the gains from job mobility, but the two are probably not independent.

b. Beyond age 50 we estimated a significant depreciation rate that increases with age.

c. In the analysis of younger men we find schooling and work both overlapping and recurrent, particularly after high school graduation. The analysis of determinants of individual differences in this transition from school to work and of their effects on subsequent experience and earnings is almost completed. In the analysis of younger men we find an appreciation (maturation) effect net of detailed accounting for work, school, and army experience. This effect diminishes rapidly and does not persist beyond teenage. Its significance for previously estimated post-school investment profiles is that their initial values were overstated mainly for workers who had a high school education or less.

d. The explanatory power of the earnings function is significantly increased by accounting for the effects of job mobility. Thus, the cross-section earnings functions that perforce ascribe the same amount of post-school investment to individuals of a given age and schooling level understates the potential power of our analysis, as was suggested in previous work with cross sections.

2. We are able to decompose returns to inter-firm mobility and to intrafirm job progress using the Coleman-Rossi data. These data contain both work and earnings histories for men up to their mid-30s. Determinants and consequences of each of these components of post-school human capital investment are under study. In accounting terms it appears that on-the-job progress (measured in dollars) is about as important as job mobility for persons with low levels of education, but the importance of the former factor grows rapidly with education, whereas the latter factor is not much affected by it. These results are consistent with both a positive relation between school and post-school on-the-job training and with search for

training options in addition to immediate wage gains as motivations in labor mobility, particularly in the earlier half of a person's working life. This work, largely in association with Ann Bartel, will be extended to the older cohorts for which some earnings history related to job intervals is available in the NBER-Th sample.

3. The Coleman-Rossi sample provides the opportunity to study both wage rate and hours of work histories. Linda Leighton is analyzing the hours (and weeks) of work profiles as well as serial correlations in wages and in hours, and together with Borjas we have started to fit individual wage rate and earnings functions to the data. The estimated parameters will provide information on individual differences in initial (post-school) earning capacities and in returns to post-school investment. We will then proceed to analyze the distributions of these individual parameters utilizing parental background and ability measures.

4. We are currently extending our analyses to the now available panels of middle-aged men and women covering the years 1966–1971. This information also permits an analysis of early retirement of men. (The fraction who had retired grew from 4 percent to 14 percent as the men aged from 1966 to 1971.) Together with Solomon Polachek we will follow up our 1966 analysis of the earnings of women and extend it to the 1966–1971 panel. Since about 20 percent of women re-enter the labor market each year, we should get an almost complete coverage of the market wages and labor supply of women who ever return to work.

Jacob Mincer

An Analysis of Job Investment and Mobility Investment

My research is concerned with an analysis of the determinants of investment on the job and investment in mobility and the differential effects of these two types of investment on wage growth over the life cycle. The Coleman-Rossi Retrospective Life History study provides a rich data set for the study of these problems since it contains information on starting and ending earnings and hours for every job an individual held from the time he entered the labor force until the date of the interview as well as detailed information on geographic mobility over the life cycle.

Using the Coleman-Rossi data, my preliminary calculations show that the average white male with fifteen years of labor force experience spent $13,000 on job investment and $5,600 on mobility investment. (These figures are net of economy-wide increases in productivity.) The mobility investment figure can be separated into $5,350 for voluntary mobility and $250 for involuntary mobility. I have also found that although education has a positive and significant effect on both total job investment and average job investment (i.e., total investment/number of firms), it does not have a significant effect on either total mobility investment or average mobility investment. However, an increase in education will increase total (job plus mobility) investment. The data also indicate a significant tradeoff between job investment and mobility investments; holding education and experience constant, a $1.00 increase in mobility investment decreases job investment by approximately $.47.

In order to examine the effects of firm mobility on wage growth over the life cycle, a regression of percentage wage growth from the first job to the current job was run on the following variables: education, experience, percentage change in hours per week, a dummy variable for change in occupation, total number of quits, total number of layoffs, and total number of job changes within a specific firm (i.e., promotions). For the entire sample, number of quits and number of promotions had positive and significant effects, with quits having a stronger effect. When the sample was segmented by education, quits had a positive and significant effect whereas number of promotions was insignificant for the sample with less than twelve years of education. For those individuals with twelve or more years of education, however, number of quits was insignificant whereas promotions had a positive and significant effect. These results indicate that highly educated people achieve wage gains by investing in skills to be used in a particular firm, whereas individuals with little education get wage increases through mobility investment.

Ann P. Bartel

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Structural Relationships Among Early Background, Cognitive Abilities, Schooling Attainment, and Lifetime Patterns of Earnings and Occupation

My work is concerned with the analysis and estimation of a structural model of lifetime patterns of earnings and occupational attainment. This study provides an analysis of a broad range of issues in a single analytical framework. The issues pertain to (1) the direct and indirect effects on earnings and occupational choice of family and social background; (2) the effects on earnings and occupational choice of several types of ability, including reading comprehension, mathematical ability, mechanical dexterity, physical dexterity, and general information; (3) intergenerational mobility in educational attainment and occupation; and (4) nonlinear relationships (especially interactions) among abilities, schooling, and age in their influence on earnings and occupational choice. The unique features of the NBER-Th data used for this study include (1) multiple measures of several specific types of abilities; (2) earnings and occupation data for the same individuals at several points in their lifetime (ages 18 to 54); and (3) detailed socioeconomic background data, including information on mother's work history, father's occupation, and parents' education.

Several methodological problems arise in developing appropriate statistical techniques for incorporating the unique features of this model and data. First, we are dealing with life-cycle behavior and multiple observations on each individual's age-earnings-occupation profile. Second, there are multiple measures of various abilities that must be synthesized within the context of this model. Third, we observe a narrow range of cohorts (born 1919 to 1925) over most of their lifetime and over a wide range of years (1945 to 1970), which confounds cohort, age, and year effects.

An important factor is the issue of intergenerational mobility. I am studying the mobility of sons with respect to schooling attainment relative to parents and with respect to occupation relative to father. For example, how much of the family's effect on schooling, occupation, and earnings operates indirectly through the development of various types of cognitive skills? Occupational mobility from generation to generation becomes a more complex but a more meaningful problem when occupational changes over the son's lifetime are considered.

My work this past year has concentrated on ways to make estimated earnings functions more useful in studying a variety of questions and on the implications of observed nonlinearities in the earnings function. This work focused on a unified development of topics in the area of earnings and human wealth distributions, including (1) optimal investment behavior implied by the life-cycle human capital investment model; (2) estimation of the basic age-earnings relationship implied by that model; (3) estimation of human wealth defined as the present value of net earnings over the entire lifetime and the implied rate of return of schooling; (4) relevant statistical distribution theory necessary to study the distribution of earnings and human wealth; and (5) the comparison of inequality of earnings and inequality of human wealth.

I have studied the comparative statics of the solution to several special cases of the Ben-Porath (1967) type of human capital investment model. These assumptions are spelled out in "The Distribution of Earnings and Human Wealth in a Life Cycle Context," which will appear in the NBER Income and Wealth Conference volume *The Distribution of Economic Well-Being*, F. Thomas Juster, ed.

Empirically I have estimated age-earnings relationships represented by an earnings function. The purpose of the estimation is to obtain the "best" polynomial nonlinear estimates of the age-earnings profiles as functions of schooling, ability, and age, allowing complete interaction among the three variables. By the criteria of the smallest residual variance, the estimated earnings function is cubic in the age variable and quadratic in the schooling and ability variables.

From these earnings functions I have estimated human wealth by integrating the earnings function from the age at which the individual left school to the age at which he retires. The present values are discounted to age 16 for all individuals and are in real 1970 dollars. Various real discount rates are employed and the results

show human wealth as a function of years of schooling, level of measured ability, and the age at which the individual is assumed to retire.

I have estimated rates of return to schooling from the estimated earnings function which is polynomial in age, schooling, and ability. I have compared these estimates with rates of return to schooling estimates from log-linear earnings functions. This analysis provided some indication of the sensitivity of estimates of rates of return to the specification and method of estimation. Since policy recommendations are often made on the basis of rates of return to particular investments, the method of calculation and estimation procedures may be crucial. One of the important conclusions that I reach in my study is that rate of return to schooling, when calculated by equating present values of age-earning streams for consecutive years of schooling, is not equivalent to the coefficient on schooling on the semilog earnings equation. The differences result primarily because of the important interactions between schooling and age and ability.

TABLE II-10

Estimated Net Increment to Human Wealth Due to Increased Schooling

Real Rate of Discount	Ability	College Graduate vs. High School Graduate	Ph.D. or Professional Degree vs. College Graduate
0%	High [a]	$71,689	$142,787
	Average	58,757	131,285
	Low [b]	58,963	58,462
3%	High	9,181	42,531
	Average	3,932	35,612
	Low	3,652	4,281
5%	High	−6,170	17,440
	Average	−9,587	12,560
	Low	−10,917	−6,423

NOTE: In real 1970 dollars, for the NBER-Th sample.

a. One standard deviation above mean ability.

b. One standard deviation below mean ability. See Lillard (1975), NBER Working Paper No. 80.

TABLE II-11

Mean and Coefficient of Variation of Annual Earnings and Human Wealth for Fully Employed Males Aged 18–64 With at Least a High School Degree

Item	Mean	Coefficient of Variation
Earnings by Age		
18–64	$ 6,429	.83
22–24	4,023	.57
25–29	5,092	.54
30–34	6,674	.58
35–44	7,900	.69
45–54	9,050	.88
55–64	9,704	1.07
Human Wealth at Age 16 by Discount Rate		
3%	$198,240	.49
5	121,943	.51
7	79,948	.51

NOTE: Earnings distributions calculated from 1960 Census population tabulations. Human wealth distributions calculated from NBER-Th estimated earnings function and using 1960 Census schooling distributions and correction for error variation.

From the estimated earnings function I have estimated the distribution of earnings and human wealth. The resulting estimated distributions of human wealth (corrected for error variation around the prediction) show lower relative variation than the distribution of observed earnings of employed males [a coefficient of variation of 0.51 (discounted at 5 percent) compared to 0.83].

Lee A. Lillard

The Earnings of Scientists

I have begun a study of the earnings of scientists in the 1960s using data from the National Science Foundation's National Register of Technical and Scientific Personnel. The data that I am using include three cross-sectional samples for 1960, 1966, and 1970 and a longitudinal sample from 1960 through 1970.

I developed a simple model of investment in on-the-job training that facilitates the simultaneous analysis of single cross-sectional, pooled cross-sectional, and longitudinal data. In its simplest version the model reveals that during

the investment period the log of earnings of each individual grows at a constant rate. The value of this constant depends on the basic parameters of the on-the-job training process and is therefore different across individuals. Specifically, the model predicts that the rate of growth of earnings during the investment (on-the-job) period increases with ability (to learn on the job) and decreases with the interest rate and with the depreciation rate of human capital.

I add a vintage hypothesis whereby individuals who entered the labor market at a later date possess a superior learning technology both in school and on the job. Because of the general accumulations of knowledge, a person of newer vintage benefits more from school for a given amount of his own resources. Furthermore, as a result of his better (more recent) schooling, he finds it easier to learn on the job. If this process evolves smoothly over time, the following relation among cross-sectional, pooled cross-sectional, and longitudinal data holds. Each individual will experience a constant rate of growth. Since the rate of growth is higher for individuals of more recent vintage, the cross-sectional data (describing earnings of different individuals at a point of time) will show a smoothly concave relation between earnings and experience. In particular, if the individual slopes depend linearly on vintage, then the implied cross-sectional relation is such that log earnings is a quadratic function of experience. Furthermore, the slope with respect to experience will be higher in later cross sections.

Finally, one can explain some of the differences in cross-sectional relations across scientific fields. That is, if one fits the relation $\log y = a_0 + a_1 \text{(experience)} + a_2 \text{(experience)}^2$ to a cross section, scientific fields in which knowledge advances rapidly will exhibit larger absolute values for a_0 and a_2. The effect on a_1 is ambiguous. It is important to point out that if vintage effects were limited only to schools, without any effect on the efficiency of learning on the job, the results would be quite different. In this case the simple model predicts that a_2 will be zero and that in rapidly advancing fields a_1 will be relatively small.

The basic difficulty in identifying vintage effects on the slope of the log earnings profile is

attributable to the close relation between vintage and experience. For instance, a quadratic form within a given cross section may well result from nonlinear individual profiles with no vintage difference among individuals. I attempt to reduce this multicollinearity problem in two ways. First I introduce nonlinearities into the individual profiles in a way that is not directly collinear with vintage. The basic idea is that a possible lower slope for higher experience level is in part a reflection of age effects whereby older individuals are less efficient in producing new human capital or have less economic incentive to invest in it. Second, I pool successive cross sections to allow variation in vintage for a given level of experience.

Preliminary estimates are already available for Ph.D.'s in seven scientific fields (agriculture, biology, chemistry, earth sciences, mathematics, physics, and psychology). These results indicate a significant vintage (year of highest degree) effect on the efficiency of learning on the job in all fields except agriculture and psychology. Significant age effects are found in all fields.

My immediate plan is to derive similar estimates of the experience, vintage, and age effects for other levels of schooling (i.e., B.A. and M.A.). The next step will be to use the available longitudinal data to estimate the various separate effects from a simple first-order difference equation in the log earnings of each individual.

I hope to use the N.S.F. longitudinal data for other purposes as well. I plan to provide a description of mobility patterns and of the development of the whole distribution of income (as distinct from an analysis of means).

<div align="right">Yoram Weiss</div>

Black-White Earnings and Employment: 1960–1970

In this paper, we examine several aspects of relative black-white male earnings between 1960 and 1970 using the 1960 and 1970 1/100 samples of the U.S. Census. A number of patterns were apparent. First, the wide earnings differentials that existed in 1960 were partly eroded, but as of 1970, remained wide. Second, black-white earnings ratios were highest for those we estimated as having entered the labor market

during the 1960s and they were even higher for those entering between 1965–1970 than for the 1960–1965 entrants. Third, the gains that occurred between 1960 and 1970 were broadly based across education and experience groups, although the most spectacular improvement occurred among college-educated blacks. Although some of the gains were attributable to the improved business cycle conditions in 1969 relative to 1959, some of the improvement also stemmed from increases in relative schooling attainment of blacks, migration of blacks from the South, and increases in relative black wages in the private sector.

In other sections of this paper, other aspects of the black and white income distributions were investigated. We found that income inequality for blacks defined as the log variance of earnings far exceeds that of whites. This may be attributed in part to (1) greater employment instability for blacks, (2) larger variation in wages for blacks, and (3) wider dispersion in schooling for blacks.

In the final section of this paper we examined occupational distributions for blacks and whites. We found that these distributions are beginning to converge, with young blacks looking very much like young whites in terms of the occupations they are entering. This paper will be published in a forthcoming NBER Income and Wealth volume edited by F. Thomas Juster.

<div align="right">James P. Smith
Finis Welch</div>

Asset Management as a Productive Activity

A paper entitled "On the Theory of Productive Saving" has been completed and distributed as NBER Working Paper No. 71. The paper, co-authored by myself and Uri Ben-Zion, sets up a framework for the analysis of asset management as a productive activity.

Our basic hypothesis extends a line of thought developed by Alfred Marshall in connection with his distinction between "gross" and "net" interest on capital. Although recognizing that gross interest typically includes some insurance against risk, Marshall also stressed that it includes "earnings of management of a troublesome business" and that in some cases it may

consist almost entirely of "earnings of a kind of work for which few capitalists have a taste." But whereas Marshall ascribed the willingness to engage in the kind of work underlying the management of certain assets basically to peculiar individual preferences, we propose that an investor's willingness to devote resources to the management of capital assets is negatively related to his management costs and positively related to his expected gains, determined, in part, by his specific training and experience. Details of these assumptions, along with some conventional assumptions concerning the utility of lifetime consumption and bequest, form the basis for the development of a life-cycle model of consumption, work, and asset-management activity.

To introduce systematically the novel implications of the basic hypothesis treating asset management or portfolio administration as a productive activity, the life-cycle model developed in this paper abstracts from an explicit analysis of the joint accumulation of human and physical capital by treating human capital endowments as exogenously (independently) determined. It also abstracts from any analysis of nonneutral attitudes toward risk so that differences in rates of return on portfolios of capital assets are traced exclusively to differences in resource allocations to productive management of assets. The basic implications of the model nonetheless are general since they apply to rates of return achieved on capital assets classified in the same objective risk class.

The set of behavioral implications derived from the model follows essentially from the hypothesized interactions between allocations of resources to asset-management activities and the level of human and nonhuman capital assets possessed by consumptive units. The main results concern the allocations of productive and consumptive resources throughout the life cycle and the interdependencies among these allocations. The analysis indicates that the magnitude of owned, hired, and borrowed resources generally is an increasing function of net worth. It also implies that the paths of human and nonhuman capital accumulation together determine the allocation of productive resources between wage and nonwage earnings-generating activities.

Some of the variation in the extent of participation in conventional "work" over the life cycle might be explained through consideration of nonhuman capital accumulation paths as derived in this paper. The model also yields specific implications concerning borrowing for investment activities and provides an explanation for apparent differences in the amount of borrowings undertaken by self-employed consumption units relative to salaried units in the same net worth class.

The analysis implies that since the magnitude of resources devoted to asset-management activities, in turn, affects the (gross) private rates of return on capital assets, differences among consumption units in their allocation of consumptive resources over the life cycle may result largely from differences in their private (gross) rates of interest rather than in their subjective time preferences or attitudes toward risk. Perhaps the most intriguing behavioral implications developed in this paper concern the association between the propensity to save and wealth, without resort to any systematic association between time preference for consumption and wealth. The analysis also provides consistent explanations for evidence reported in the literature concerning differences in *average* propensities to consume across occupational and racial groups without reference to variation in transitory components of measured income. The analysis thus complements the permanent income hypothesis in explaining reported variations in marginal and average propensities to consume across these groups.

Work in progress includes relaxation of most of the simplifying assumptions underlying the analysis in the first paper. One of the main issues under investigation is the full nature of the interdependence among risk, return, and productive management of assets. The empirical investigation attempts to estimate nonwage income-generating functions by relating risk adjusted levels of portfolio returns to the basic determinants of the allocation of resources to asset management. It also attempts to explain portfolio choices concerning "risky" and "less risky" assets as a function of those basic determinants. The data on portfolio composition and portfolio returns is taken from the *Survey of Financial Characteristics of Consumers* (1963) and *Survey of Changes in Family Finances* (1964) initiated by the Board of Governors of the Federal Reserve System.

<div style="text-align: right">Isaac Ehrlich</div>

Education and Screening

In the past year I have completed a paper on education and screening. This paper explores some of the recent questions raised about the underlying nature of the relationship between income and schooling. The issue revolves around the extent to which formal schooling serves to augment worker productivity and, thus, social product, as opposed to conveying information to employers about the probable capabilities of prospective employees without affecting those capabilities.

First, a theoretical model of this latter screening role was explored. The basis for this model was that individual productivities are unknown to the firm prior to hiring and are neither instantaneously nor costlessly determinable from direct observation of on-the-job performance. The information available to the firm was restricted to knowledge of the first two moments of the population's skill distribution, with output a function of occupation-specific aggregate skill levels and capital. Within an expected profit maximization framework, uncertainty in the form of skill variance led to a reduction in expected profits at the previous input scales and to substitution and production effects on employment. Furthermore, the demand for workers associated with a given schooling class depended on both the average skill level and the variance-mean skill ratio of the group. Thus, schooling's private return could be viewed as a reflection of its informational content; i.e., its sorting function. In addition, eliminating between-group skill variance through the use of identification or screening devices led to a more efficient allocation of workers both within and across firms.

Several tests aimed at distinguishing between the two views were conducted. A comparison of self-employed and private wage workers with respect to their schooling decision and the life-cycle effects of schooling on earnings yielded results that raise doubts about the significance

of the screening interpretation of the income-schooling relationship.

Kenneth Wolpin

The Relationship Between Schooling and Wealth

My research focuses on several aspects of the relationship between schooling and wealth: the impact of schooling on earnings over the lifetime, the part-time earnings of students, and the demand for schooling as a consumption good. In "Age, Experience, and Wage Growth" (NBER Working Paper No. 51), I devised a method through which one may infer how much human capital formation occurs at various stages in a lifetime. The National Longitudinal Survey of young men is used to study the growth in hourly wage rates over a three-year period, 1966–1969. The major empirical finding of this study is that work experience plays an important role in the determination of wage growth. This results from investment in on-the-job training: young men invest the equivalent of anywhere from one-fifth to one-half of their earnings in job training. Aging per se, however, contributes substantially to wage growth by providing another form of human capital. The importance of aging declines substantially with age so that while at 19, one year of aging, net of experience, implies twice as much wage growth as one year of experience. By the time the individual has reached 25, the effect of experience exceeds that of aging. In addition, race, marital status, and unionization affect wage growth and investment in on-the-job training.

I have completed a preliminary draft of a paper entitled, "Schooling as a Wage Depressant," in which I argue that individuals who are currently attending school are willing to accept lower wages in order to obtain part-time jobs that complement their schooling. The effect turns out to be extremely strong. By dropping out of school, an individual increases his current wage by about 15 percent.

In a third paper, "Education: Consumption or Production," I develop a model in which education affects the individual's welfare in two ways. It affects his ability to earn wages in the usual sense, but it also enters his utility function directly because of the consumption aspects of education. The model treats education as a joint product and it permits me to estimate the rental value of a unit of education used in the labor force as well as the parameters of a utility function. In addition, in this framework, one can sort out the effect of differences in IQ and family background on optimal investment and consumption of education. The major finding is that education is a "bad"—i.e., it enters negatively into the individual's utility function. The wealth-maximizing level of education exceeds the attained level for 97 percent of the individuals in the sample. Furthermore, parental education affects initial wages (schooling costs) by much less than it does the returns to education so that both actual and wealth-maximizing levels of education vary positively with parental schooling. The effect of IQ, on the other hand, is neutral with respect to costs and returns to schooling. Most important is that the rental price to education is positive and substantial. The wealth-maximizing level of education is found to be sixteen years for the mean individual. The fact that the mean level is twelve years is consistent with the finding that education is a "bad."

Edward P. Lazear

Determinants of High School and College Completion Rates

I am continuing my study of differences in schooling attrition rates across individuals and groups. The decision to drop out of an educational program is viewed in the context of conditional probability theory, wherein the expected value of a completed degree varies with differing rates of unemployment for dropouts and graduates, the present value of the anticipated graduate/dropout earnings differential, and the costs incurred by the student enrolled in school.

My empirical research distinguishes the significance of race, sex, academic ability, family background, and school characteristics as determinants of the propensity to drop out. The samples of young men and women from the National Longitudinal Surveys provide a data base for testing the model. High school and college cohorts are followed from matriculation

through completion, allowing me to estimate changing probabilities of attrition over sequential years of enrollment in high school or college, and variation in the probability of completion given entry into the first, second, third, and fourth years of conventional credential programs. Secondary characteristics such as school size, teacher salaries, and dollar expenditures per student are analyzed for their effects on high school completion rates and subsequent behavior, and labor market characteristics in the area of residence are examined to determine their impact on the incentive to complete school. Using endogenously determined completion and employment probabilities, and exogenously calculated graduate/dropout earnings differentials, I will be able to estimate differences in the expected value of school completion for various subsets of the population.

Kathleen V. McNally

The Taxation of Human Resources

During this past year, my work has focused on two topics: the taxation of human resources and the effects of social security on the retirement and labor supply decisions of the elderly population. On the former topic, I have revised (substantially) two papers and have neared completion on a third; on the latter topic, I have finished a paper reporting on some preliminary results.

The two revised papers, "A Markov Model of Aid to Families with Dependent Children," and "Efficiency Aspects of the Differential Tax Treatment of Market and Household Economic Activity" are forthcoming in the summer 1975 *Journal of Human Resources* and appeared in the February 1975 *Journal of Public Economics,* respectively. In the former I document the enormous turnover in the welfare population and estimate a very large differential in the probability of leaving, and the probability of returning to, welfare dependency, depending on whether heads of families receive wages below or above the minimum wage. The revision incorporates suggestions made at an NSF-NBER conference on decision rules in March 1974. In the latter I recast the concern over the differential taxation

of market and household activity in general equilibrium terms and estimate a rough lower bound to the dead-weight loss induced by the current tax treatment of $40 billion per year; I also explore the structure of optimal taxation when household labor cannot be taxed. Among the results I derive is an estimate that the substitution of a value-added tax for the residential property tax would dramatically worsen resource allocation.

The theoretical work for a paper entitled "Tax Incidence in an Economy with Human Capital Accumulation" has been completed and I am now making some numerical simulations of alternative tax policies. In the paper I focus on two key parameters: the amount and rate of return sensitivity of human capital accumulation.

A paper entitled "Social Security and the Labor Supply and Retirement Decisions of the Elderly Population: Some Preliminary Results" is now completed. This paper is based on data from the Panel Study of Income Dynamics to follow the labor supply and retirement decisions of an elderly age cohort from 1968 through 1972. I use a variety of estimation methods to attempt to estimate the impact of social security benefits and the earnings test on retirement decisions. The preliminary results suggest that social security benefits and the earnings test have substantial effects on labor supply and retirement decisions, a finding consistent with the aggregate time series evidence reporting a sharp decline in the labor force participation rates of aged workers and a simultaneous rapid expansion in social security benefits.

Also, a brief critique of the New Jersey negative income tax experiment was presented at a Brookings Institution conference and will appear shortly in a Brookings volume.

Michael J. Boskin

Variation Across Households in the Rate of Inflation

As a part of our research program on the distribution of income, I have recently conducted an empirical study of the distribution of inflation rates among households. The results are reported in NBER Working Paper No. 74. For the study I used a large cross-sectional survey of

households in 1960–1961 to obtain information on the composition of the market bundles of goods and services purchased by each of several thousand households in the U.S. I also used published data for the U.S. on monthly changes in the separate indexes of prices of some fifty expenditure items that comprise consumers' market bundles. With information on price changes for these fifty items and the composition of households' consumption bundles, I computed a price index for each of some 11,000 households separately for several recent time periods. I studied the distributions of these price indexes and investigated the relationships between household characteristics and the indexes.

The empirical estimates indicate the magnitude of the effect of recent periods of inflation on the relative prices of various households' market bundles. I also investigated which types of households have encountered the highest price increases. The findings should be of interest in light of the frequent discussion of the distributional impact of inflation. The study also provides information relevant to the public discussion of the usefulness of income-group specific consumer price indexes.

The following findings have emerged from the study:

1. There is considerable dispersion among households in the computed price indexes. Table II-12 shows the average increase in the price indexes for 11,761 nonfarm households, together with the standard deviation and the coefficient of variation in the price increases among those households over several time periods. The table indicates, for example, that for the first six months of 1974 the average price index rose by 6.0 percent, but the standard deviation across households was 1.2 percent. These household-specific price indexes for this six-month period ranged from a low of 2.0 percent to over 13.0 percent. Approximately one in ten households experienced a price increase of less than 4.6 percent in that six-month period whereas another one in ten households experienced a price rise of more than 7.4 percent.

2. There is a tendency for the relative dispersion in the price indexes across households to be smaller when calculated over longer time

TABLE II-12

Percentage Change in the Price Index

Time Period	Mean	Standard Deviation	Coefficient of Variation
1967–1972	22.54	2.92	0.13
1972	3.14	0.58	0.18
1973	9.82	2.33	0.24
January 1974	1.09	0.49	0.45
February 1974	1.43	0.36	0.25
March 1974	1.08	0.30	0.28
April 1974	0.47	0.19	0.40
May 1974	0.95	0.14	0.15
June 1974	0.78	0.15	0.19
January–June 1974	6.03	1.19	0.20

periods.

3. In several particular time periods there are sizable and statistically significant relationships between the increase in the household's price index and certain demographic and economic characteristics of the household. For example, over the year 1973 or the month of January 1974 the price index rose relatively rapidly for households with low after-tax family income or with households headed by individuals characterized by low levels of education or older age. However, the importance of these, and other, relationships between the price changes and the household characteristics is diminished by two other findings:

4. When the households are combined into relatively homogeneous groups defined by income, education, age, city size, marital status, race, etc., the within-group dispersion in price indexes is still very substantial. The dispersion within groups tends to dominate the differences in group means.

5. Although there are sizable and significant relationships between the price change and household characteristics during specific time periods, none of these relationships appears to be stable over time. None of the household characteristics studied, in fact, exhibits a consistently positive or negative simple or partial relationship with the price changes over the several time periods investigated.

6. There is, however, evidence of a positive covariation over time in the rates of price changes

across households. That is, the correlations across households between the rates of price increase from one time period to the next are positive. For example, among the nearly 9,000 married couples in the study, the simple correlation between the household's price change in the year 1972 and its price change in the year 1973 was +0.63. Those couples that experienced higher than average increases in the price of their market bundle in 1972 tended to have the same experience in 1973. Of course, evidence from successive months or even years does not necessarily constitute independent evidence if one considers an episode of price adjustments as a single relevant "observation." That is, the recent rises over several months in the prices of oil products and perhaps food might constitute one observation or one degree of freedom in considering serial correlations or time-dependent covariation in price rises. Thus the month-to-month, and recent year-to-year, positive covariation over time should be interpreted cautiously. It would be inappropriate to generalize about covariation over long time periods from the results presented in this paper.

As with every study, there are important limitations to be mentioned. The price indexes computed here are Laspeyres indexes with fixed (1960–1961) weights; hence we observe how the price of a fixed bundle of goods changes for each household, but not how the composition of the bundles themselves change in response to the relative price changes in the market place. Furthermore, since prices actually paid for specific goods and services are not observed for each household separately each month, it is assumed here that the same average price change for a specific item is experienced by all consumers. Hence only the differences in the composition of consumption bundles can generate dispersion in the calculated price indexes.

There is another limitation, perhaps more important. Inflation may affect real income not only by exerting a differential impact on consumers' price indexes but also by affecting, say, money earnings and the value of financial assets. But this study does not investigate these influences. Put differently, the study reported here yields answers to such questions as, "Have the consumption bundles typically purchased by the elderly risen in price more rapidly in recent years than the bundles typically purchased by middle-aged couples?" But the study does not address such questions as, "Has the inflation in recent years affected the money incomes of the elderly differently than it has the money incomes of working prime-aged couples?" Without answers to both these (and additional) questions one cannot conclude anything about the net impact of inflation on the relative position of one group or another in the distribution of real income. In this important sense, the study reported here is a partial analysis.

Robert T. Michael

Quality of Education and Productivity

The project on the Quantity and Quality of Educational Attainment came to an end in the past year. Two final papers have been revised and are forthcoming in *Explorations in Economic Research*: "The Effect of School Quality on Achievement, Attainment, and Lifetime Earnings" by Paul Wachtel; and "The Definition and Impact of College Quality," by Lewis Solmon. The results in these papers were discussed in last year's *Annual Report*. Another paper that included some final results was "The Effect on Earnings of School and College Investment Expenditures" by Paul Wachtel. In this paper I examine the effect of school expenditures at the college and pre-college levels and the tradeoff between them. Only very large changes in annual school expenditures are equivalent to an incremental year of schooling. Furthermore, both school and college expenditures have a significant effect on earnings. Pre-college school expenditures affect earnings directly, even for those who go on to higher education.

My primary Bureau activity in the past year has been to lay plans for a new project, Measuring the Productivity of Schools and the Allocation of Educational Resources with Longitudinal Student Data: A Study of Educational Production Functions. Professor Linda Edwards of Queens College and I will be the co-investigators on this project. We have conducted an

investigation of the educational production function literature and outlined some plans for future work. This literature is inadequate because of the poor data analyzed and because of the procedures employed. We hope to remedy both of these problems with an analysis of data from the National Longitudinal Study of Mathematical Abilities. We have obtained some of the data and are in the process of conducting some preliminary studies.

Paul Wachtel

Law and Economics

Introduction

The past year's research activity, which is described in more detail in the individual reports that follow, includes the following studies: Isaac Ehrlich's study of the deterrent effect of capital punishment in the U.S. based on time series and cross-sectional data (the time series analysis was published in the *American Economic Review,* June 1975); William M. Landes and Richard A. Posner's work on private enforcement (which appeared in the *Journal of Legal Studies,* January 1975) and their study of the federal courts from 1873–1974; Posner's analysis of theories of regulation (which appeared in the *Bell Journal of Economics and Management Science,* autumn 1974) and his work on the social costs of monopoly and regulation (which is forthcoming in the *Journal of Political Economy*); B. Peter Pashigian's study of the economics of the legal profession; Sam Peltzman's empirical analysis of the effects of federal regulation of motor vehicle design (which will appear in the *Journal of Political Economy*) and his study of antitrust policy; Melvin W. Reder's work on medical malpractice; and George J. Stigler's study of the structure of legislatures. In addition to these publications, Ann Bartel's study of private protection against crime (described in last year's *Annual Report*) appeared in the *Journal of Legal Studies,* June 1975.

Pashigian and Peltzman joined the law and economics program this year as senior research associates. The law and economics program is being supported by grants from the National Science Foundation and the American Bar Foundation (which is funding Pashigian's study of the legal profession).

William M. Landes

Capital Punishment

The initial phase of my study of the deterrent effect of capital punishment is complete. The theoretical formulation and time series analysis, which are described in last year's *Annual Report,* was published in the *American Economic Review* in June 1975. This paper employs a simultaneous equation model that incorporates both the offensive and defensive aspects of acts of murder. The model is tested against data for the United States from 1933 to 1967.

The second stage of the study is in progress and will augment the first in several respects. The deterrent effect of the death penalty is being tested against an independent, cross-sectional body of data. These data permit the measurement of a severity of imprisonment variable, which was not available in the time series analysis and allow states that impose the death penalty to be separated from those that do not. Among the states that do not impose the death penalty, those with legislation prohibiting capital punishment can be distinguished from those in which the death penalty is not enforced. These distinctions provide the basis for further analysis of optimal defense against murder by examining the tradeoffs in the use of alternatives for combating murder. A related issue under study is the role of equity in applying the death penalty and punishment in general.

Isaac Ehrlich

Private Law Enforcement

This paper is a continuation of the economic study of the law-enforcement process begun by Gary Becker and George Stigler in their article "Law Enforcement, Malfeasance, and Compensation of Enforcers" (*Journal of Legal Studies,* January 1974). The paper presents a formal model of law enforcement by profit-maximizing individuals or firms, under various assumptions concerning the structure of the industry (whether competitive or monopolistic) and the system of

property rights that enforcers are accorded in offenses. A major result of the formal analysis is the "overenforcement theorem," which holds that private enforcement results in excessive enforcement activity compared to optimal public enforcement. We show that this theorem holds regardless of the precise assignment of property rights in offenses or the competitiveness of the enforcement industry. The relationships between the "overenforcement theorem" and taxation of enforcers, nonmonetary sanctions, and legal error are also analyzed.

The theorem embodies a number of implications for the positive analysis of the legal system, which we explore. The public monopoly of law enforcement in some areas of the law, but not others; the budget constraints of public enforcement agencies; discretionary nonenforcement of the law; and the legal attitude toward blackmail and bribery are among the phenomena that we demonstrate are illuminated by the economic analysis of private enforcement. An appendix considers the economics of rewards as a method of compensating private enforcers. The paper has been published in the January 1975 issue of the *Journal of Legal Studies*.

<div align="right">William M. Landes
Richard A. Posner</div>

and procedure and to answer policy-oriented questions such as the costs in judicial resources of different types of cases, the productivity of federal judges over time, the costs of reducing or eliminating the court queue, and the effect of the Warren Court's criminal procedure decisions on the current workload of the federal courts. In subsequent studies in this series, we hope to do a cross-sectional analysis using data from the various federal districts and circuits and to include state-court as well as federal-court data in our studies. Posner's study of administrative delay, referred to in last year's *Annual Report*, will be incorporated into this series of studies.

As a spin-off from our larger study of the federal court system, we are presently at work on a paper dealing with the question whether the institution of an independent judiciary can be reconciled—as we believe it can—with the economic theory of government proposed by Stigler and others, which emphasizes the role of interest groups in policy formation. A preliminary draft of our paper was given in April 1975 at a Conference on Economic Analysis of Political Behavior organized by the Universities-National Bureau Committee on Economic Research.

<div align="right">William M. Landes
Richard A. Posner</div>

The Federal Courts, 1873–1974

We have begun work on a large-scale theoretical and empirical study of court systems. The first stage in this study is a time series analysis of the federal courts from 1873 (the first year for which data are available) to the present. We have collected (mainly from the annual reports of the Attorney General and, since 1940, of the Director of the Administrative Office of the U.S. Courts) data concerning number of cases of different types filed, terminated, and pending; backlogs and court queues; trials and appeals; number and salaries of judges and other personnel of the federal court system, and other budgetary information; and other data related to the demand for and supply of federal judicial services. We plan to use these data both to test various hypotheses about the judicial process derived from the economic theory of litigation

Theories of Economic Regulation

Several theories have been advanced to explain the pattern of government regulation of the economy. These include the "public interest" theory and several versions, proposed either by political scientists or by economists, of the "interest group" or "capture" theory. This study analyzes those theories. In it I argue that the public interest theory and the political scientists' versions of the interest group theory are unacceptable in their present form. Most of the discussion concerns the economists' version of the interest group theory; its theoretical and empirical foundations are reviewed, and the conclusion is reached that, while promising, the theory requires both more analytical development and new sorts of empirical investigation before it can be accepted as an adequate positive theory of regulation. The study was pub-

lished in the *Bell Journal of Economic and Management Science,* autumn 1974.

Richard A. Posner

The Social Costs of Monopoly and Regulation

I have completed a theoretical and empirical study of the social costs of monopoly and regulation. In previous studies attempts were made to measure the social costs of monopoly by estimating the "welfare triangle," which results from the reduction of output below competitive levels. In the present paper, which builds on earlier work by Gary Becker on the costs of theft and Gordon Tullock on the costs of theft, tariffs, and monopolies, I argue that the welfare triangle underestimates the social costs of monopoly (and monopoly-inducing regulation) by ignoring the effect of competition to obtain a monopoly in transforming the expected profits of monopoly into social costs. I develop formulas for calculating the total social costs of monopoly and regulation in the light of various assumptions regarding the shape of the demand curve confronting the monopolist. These formulas are used to derive some crude but suggestive estimates of the social costs of monopoly and regulation. The suggestions are (1) that previous studies seriously underestimated those costs, and (2) that the social costs of regulation-induced monopolies are greater in the aggregate than those of private monopolies in the U.S. today. I also discuss a number of qualitative implications of the approach taken with respect to such issues as the social responsibility of corporations and racial discrimination by labor unions. The paper will appear in the *Journal of Political Economy.*

Richard A. Posner

The Demand and Supply of Lawyers

This project is in its initial stage. My current plans are to investigate the following areas: (1) determinants of the demand for and supply of lawyers, (2) the effect of licensing and educational requirements on the mobility of lawyers and on interstate variation in lawyer incomes, and (3) the effect of schooling and experience on the level and dispersion of lawyers' income.

In some cases it will be possible to compare the legal profession with other professions requiring comparable years of schooling.

A considerable portion of the project thus far has been devoted to identifying sources of data and evaluating data quality. Published census data from 1930–1970 will be used along with the 1/100 samples for the 1960 and 1970 censuses. Licensing data are published in the *Bar Examiner,* and number of students enrolled and graduating from law schools is available in the *Review of Legal Education.* Income data are published in the *Census of Population, Statistics of Income* (Department of Treasury), *National Survey of Professional, Administrative, Technical and Clerical Pay* (Department of Labor), and in the *Survey of Current Business.* These and other data sources will be utilized.

B. Peter Pashigian

Highway Safety Regulation

I have completed a manuscript on the effects of federal regulation of motor vehicle design. The regulation is designed to reduce the expected death and injury cost when an accident occurs, and one question I address is whether drivers respond to this lower cost by running more accident risk. I also investigate whether any increased accident risk shifts part of the death and injury cost to pedestrians.

An alternative view of regulation is that it reflects, or substitutes for, privately demanded safety, in which case there would be no more accident risk and nonoccupant deaths and injuries than could be accounted for by market forces.

These issues are sorted out empirically by estimating a demand for accident and death risk in the absence of regulation and seeing how well it explains data from the post-regulation period. The basic finding is that regulation has not affected total highway deaths. Time series data imply a shift of the burden of these deaths toward nonoccupants and an increase in total accidents, but cross-sectional data fail to confirm these two results. The paper is forthcoming in the *Journal of Political Economy.*

Sam Peltzman

Antitrust Policy

I have begun a study aimed at analyzing the rationale for a policy of restricting industrial concentration or promoting deconcentration. The study is based on the voluminous existing literature on the effects of concentration, which generally shows that high concentration is associated with high profitability. This literature provides the intellectual foundation of much current antitrust policy, but fails to resolve a crucial issue: Does high profitability imply super competitive prices or is it the result of some efficiency specific to large firms, or some combination of the two? I will try to separate the cost and price effects of industrial concentration by examining census data that permit decomposition of a change in profitability into price- and cost-change components. Both components can then be examined for industries in which concentration has changed, and any relationship that emerges can be used to shed light on the costs and benefits of a policy of limiting concentration.

Most of the basic data for the study have been collected, and some very preliminary results indicate that concentration affects both costs and prices, so that the conventional interpretation of the concentration-profitability relationship may be overly naive.

Sam Peltzman

Economics of Medical Malpractice

I have completely revised the first draft of the "Economics of Medical Malpractice." I have estimated numerous equations across states for 1970 relating insurance rates (for equal degree of protection) against malpractice liability and have run separate regressions for hospitals, surgeons, and physicians. The independent variables with the highest explanatory power are per capita income, the degree to which state liability laws favor malpractice plaintiffs, number of operations per surgeon, percentage of doctors in group practice, and average number of doctors per group. In almost all cases, the logarithmic form of the estimated equation performs better than the arithmetic. The results are currently in the write-up process and a second draft should be available this year.

Work is also progressing on the analysis of strikes, lawsuits, and other forms of social conflict and a draft should be ready soon.

Melvin W. Reder

Representation and Legislatures

The nature of political representation plays a big, but little-explored role in economic legislation. I am investigating the size of legislatures, the determinants of size, and the relative powers of upper and lower houses. I am searching for criteria of efficient representation, a subject submerged in the overwhelmingly normative literature of political science.

George J. Stigler

Economics Without Taste Changes

We have drafted an essay in which we propose the working hypothesis that economists should treat the tastes of people as stable and uniform. In other words, the explanation of phenomena in terms of changes in tastes has no explanatory power, but the phenomena for which taste changes have usually been proposed as an "explanation" can in fact be fruitfully analyzed on the assumption of stable, uniform tastes. The analysis rests heavily on Becker's theory of household production functions.

The thesis is supported by the analysis of several phenomena:

1. Increasing marginal utility—e.g., hearing good music increases one's appreciation of additional music.
2. Advertising.
3. Custom and tradition.
4. Fashions and fads.
5. Time preference.

In each case the phenomenon is explained without recourse to taste changes, and new results are reached.

Gary S. Becker
George J. Stigler

Economics of Health

Introduction

The high cost of medical care continues to be one of the central topics in our research on the

economics of health, which is supported by grants from the National Center for Health Services Research (U.S. Department of Health, Education, and Welfare) and from the Robert Wood Johnson Foundation. Mark Pauly, a research fellow from Northwestern University, has been investigating the role of physicians in the demand for, and production of, medical care. Claire Bombardier, M.D., formerly chief resident in internal medicine at the Royal Victoria Hospital in Montreal, is a visiting scholar in health economics. She is analyzing the economic behavior of physicians who specialize in internal medicine. Douglas Coate of Rutgers University has joined the program as a senior research analyst. He is studying the economic aspects of optometry. Other studies that have significant implications for cost include the work of Edward Hughes, M.D., and Eugene Lewit on the utilization of surgical manpower, Victor Fuchs' study of earnings and utilization of allied personnel, Barry Chiswick's study of nursing home utilization, and Melvin Reder's study of medical malpractice insurance (see the Law Program).

Another continuing interest of the program is in health—its causes and consequences. Kenneth Warner, of the University of Michigan, has been appointed a visiting scholar and will begin work on the economic aspects of biomedical research and innovation, a subject not previously investigated by the NBER. Ultimately we may undertake a long-term project in this area that would involve several staff members. This project would investigate relationships among biomedical research expenditures, biomedical innovations, diffusion of innovations, and health outcomes measured by reductions in mortality and morbidity. Other studies reported below that have significant implications for health include Michael Grossman's study of health and consumer behavior, Marcia Kramer's study of abortion and fertility in New York City, and Eugene Lewit's study of birth outcomes and infant health.

Several new members of the support staff of the program are Kathleen McNally, a research analyst; Marilyn McDonald and Donald Wright, research assistants; and Claire Gilchrist and Catherine Grant, secretaries.

The following publications appeared last year, are in press, or are available in preliminary form.

Barry R. Chiswick, "Hospital Utilization: An Analysis of SMSA Differences in Hospital Admission Rates, Occupancy Rates, and Bed Rates," *Proceedings of the Social Statistics Section of the American Statistical Association,* 1974.

Victor R. Fuchs, *Who Shall Live? Health, Economics, and Social Choice* (New York: Basic Books, 1975).

Michael Grossman, "The Correlation Between Health and Schooling," *Household Production and Consumption,* Nestor E. Terleckyj (ed.), (New York: NBER Studies in Income and Wealth No. 40, forthcoming).

_____, review of "Mental Illness and the Economy," by M. Harvey Brenner, *American Journal of Orthopsychiatry,* Vol. 44, No. 5, October 1974.

Edward F. X. Hughes, Eugene M. Lewit, and Frederick V. Lorenzo, "Time Utilization of a Population of General Surgeons in Community Practice," *Surgery,* Vol. 77, No. 3, March 1975.

Edward F. X. Hughes, Eugene M. Lewit, Richard N. Watkins, and Richard Handschin, "Utilization of Surgical Manpower in a Prepaid Group Practice," *The New England Journal of Medicine,* Vol. 291, No. 15, October 10, 1974.

Mark V. Pauly, "The Role of Physicians in the Production of Hospital Output," NBER Working Paper No. 73, February 1975.

Victor R. Fuchs
Michael Grossman

Health and Consumer Behavior

My research focuses on the determinants of health and medical care utilization and on the effects of health on various aspects of consumer behavior. In one study I am analyzing variations in children's health in the context of a model in which children's health is viewed as one aspect of their quality. Thus, parents are said to demand healthy children, and the demand curve for children's medical care services is derived from the interaction between the demand and production functions of children's health. The production function should depend on genetic endowment, various types of medical services,

and home environmental factors such as formal schooling of parents. The principal variables in the demand curve for children's health should be the price of medical care, the opportunity cost of parents' time, parents' income, parents' schooling, and genetic endowment. This same set of variables should enter the demand curve for children's medical care.

Currently, I am preparing a data file to estimate production and demand functions from a 1970 health survey conducted by the National Opinion Research Center and the Center for Health Administration Studies of the University of Chicago. The NORC sample is an area probability sample of the civilian noninstitutionalized population of the United States. It consists of 11,619 individuals from 3,765 families. Measures of health include self-evaluation of children's health by parents, restricted-activity days, bed-disability days, number of symptoms reported from a check list of common symptoms, and presence of acute and chronic conditions. The sample contains standard information on utilization of various types of medical services, including physicians' services by type of physician and reason for visit, dental services, hospital services, and prescribed and nonprescribed drugs. It is a particularly rich source for calculating the "full" price of medical care based on a family's travel time to its usual source of medical care, waiting time for an appointment with its regular physician, waiting time in the physician's office, and various parameters of the family's health insurance policy (coinsurance rate, deductible, upper limit, etc.). The estimates of production and demand functions that I obtain from this sample should increase our knowledge of the relative contributions of medical and nonmedical inputs to children's health and of the relative effectiveness of competing policies to increase utilization of medical services by children.

In a second study I plan to examine the effects of adults' health on their consumption patterns. The household production function approach to consumer behavior serves as the point of departure for the study. This approach assumes that consumers produce their basic objects of choice, called commodities, with inputs of market goods and their own time. Within the context of the household production function framework, an increase in health may affect consumption patterns because it raises the total amount of time available for market and non-market production, raises market productivity measured by the wage rate, or raises non-market productivity. Indeed, in previous research, I have found that health is positively related to wage rates and weeks of work. Suppose that one abstracts or controls for these two factors and focuses on the impact of health on productivity in the household. As Robert T. Michael has shown (see *The Effect of Education on Efficiency in Consumption,* New York, National Bureau of Economic Research, 1972), with money income or total consumption held constant, an increase in non-market productivity should increase the consumption of luxuries (goods with income elasticities greater than 1) and should reduce the consumption of necessities (goods with income elasticities less than 1).

My initial empirical aim in this study is to test the hypothesis that health raises non-market productivity by examining whether it shifts consumption toward luxuries. In proceeding, I will use data contained in the Bureau of Labor Statistics' Survey of Consumer Expenditures, 1960–1961. Since the survey does not contain health information, I will group the families in it by, for example, marital status, age, schooling, and family income. Then I will obtain independent cell estimates of health from several health surveys that were conducted around 1960. Using ordinary least squares multiple regression analysis, I will compute income-expenditure (Engel) curves with a set of independent variables that includes "permanent income," schooling, health, and family size. If health does in fact raise non-market productivity, it should have a positive partial regression coefficient in the case of luxuries and a negative coefficient in the case of necessities.

The Engel curves that I obtain may be viewed as a subset from a more complete system of equations that also contains a wage function, a labor supply function, and demand functions for various uses of non-market time. Ultimately, I would like to fit the complete system in order to get more precise measures of the effects of health on non-market productivity. In addition,

I can combine non-market productivity effects with measures of the impact of health on wage rates and hours of work to evaluate the dollar benefits of potential improvements in health. Such benefit measures should be of use to government policymakers who must allocate scarce resources among programs to improve health and programs with other goals.

Michael Grossman

Health Manpower Study

I am using the 1/100 samples of the 1970 and 1960 censuses of population to gain a better understanding of wages in the health care sector. The study is limited to wage and salary workers with seventeen years of schooling or less (the so-called "allied health personnel," who numbered about 4 million in 1974). I am attempting to answer the following questions:

1. How do wages in health compare with wages in other non-farm industries?

2. Are there significant differences in wages within the health sector—e.g., hospitals, nursing homes, physicians' offices?

3. Have wages been rising more rapidly in health than in other industries?

4. What are the determinants of wage levels and rates of change of wages in health?

5. What are the consequences of variations in wages—i.e., is there substitution between labor and non-labor inputs or between various types of labor?

Table II-13 provides an example of the type of measure being calculated. A key concept is that of comparing the actual hourly earnings of any industry, occupation, or group with the "expected" earnings—i.e., the earnings that the group would have if each person in it earned the all-industry rate for his or her color, age, sex, and years of schooling. Actual earnings divided by expected earnings can be regarded

TABLE II-13

Earnings and Hours of Wage and Salary Workers[a]
in the Health Industry and All Industries,[b] 1969

	All	White Males	White Females	Nonwhite Males	Nonwhite Females
Annual earnings (U.S.$)					
Health	4,492	6,498	4,136	4,956	4,031
All industries	6,294	8,157	3,954	5,592	3,444
Annual hours					
Health	1,632	1,837	1,559	1,841	1,741
All industries	1,769	1,956	1,495	1,845	1,554
Hourly earnings (U.S.$)					
Health	2.75	3.54	2.65	2.69	2.32
All industries	3.56	4.17	2.64	3.03	2.22
Expected hourly earnings[c]					
Health	2.89	4.20	2.69	3.10	2.28
Hourly earnings ÷ expected hourly earnings					
Health	.95	.84	.99	.87	1.02

SOURCE: The 1/1000 (for "All industries") and 1/100 (for "Health") samples of the *Census of Population*. Calculations by the author. All ratios calculated from unrounded data.

a. All data refer to wage and salary workers with seventeen years of schooling or less.

b. "All industries" always excludes agriculture, forestry, and fisheries in this set of tables.

c. The earnings we would observe in "Health" if each worker were paid at the "All industries" rate for given color, age, sex, and schooling.

TABLE II-14

Hourly Earnings in Selected Occupations, Health and Other Industries, 1969

	Hourly Earnings ($)		Actual ÷ Expected
	Actual	Expected	
White females			
Dietitians	2.79	3.20	.87
Registered nurses	3.53	2.96	1.19
Health technologists and technicians	3.07	2.88	1.07
Teachers, except college and university	4.32	3.95	1.09
Social & rec. workers, except health	3.29	3.49	.94
Librarians	3.84	3.93	.98
Secretaries—health	2.57	2.70	.95
Other clerical—health	2.37	2.62	.90
Secretaries—except health	2.81	2.67	1.05
Other clerical—except health	2.60	2.58	1.01
Practical nurses	2.49	2.57	.97
Nursing aides, orderlies, etc.	1.88	2.41	.78
Other service workers—health	2.03	2.42	.84
Hairdressers and cosmetologists	2.15	2.41	.89
Other service workers—except health	1.83	2.38	.77
Private household workers	1.39	2.27	.61
White males			
Health technologists and technicians	3.86	4.37	.88
Craftsmen and operatives—health	3.59	4.06	.88
Engineering and science technicians	4.30	4.24	1.01
Craftsmen and operatives—except health	3.87	3.86	1.00

as a standardized wage index. Table II-14 provides an interesting comparison between

TABLE II-15

Change in Standardized Hourly Earnings in Hospitals and Other Health by Occupation, 1959 to 1969

	Actual 1969/Expected 1969	
	Actual 1959/Expected 1959	
	Hospitals	Other Health
Registered nurses	1.21	1.09
Practical nurses	1.25	1.20
Nursing aides, etc.	1.07	.99
Technologists and technicians	1.04	1.17
Secretaries	1.04	1.04
Other clerical	1.04	1.02

health occupations and other occupations, and Table II-15 shows how the standardized earnings in certain important health occupations changed from 1959 to 1969.

Some preliminary conclusions are that wages rose more rapidly in health than in other industries, particularly in hospitals, and particularly for registered nurses and practical nurses. The next stage of the project will concentrate on analyzing differentials and changes in differentials across states.

Victor R. Fuchs

The Effects of Physicians on the Demand for and Supply of Medical Care

The physician, in his role as agent for the consumer, provides medical care himself, but also causes or orders the use of other medical care.

My research is primarily intended to investigate the empirical implications of this latter role, particularly with regard to hospital care.

The physician affects the demand for medical care in two ways. First, the price the consumer pays for the physician's services affects both the amount of physician services and the amount of other medical care services demanded. Second, because the physician provides information to the consumer about the usefulness of medical care to him, and acts as agent for the consumer, the physician may affect the demand schedule directly. He may engage in nonprice rationing, and he may manipulate the information he provides in order to affect the amount or type of care the consumer agrees to buy at a given price.

On the supply side, the physician provides his own time, a productive input. In addition, he organizes parts of the production process. Physicians organize and direct ambulatory (mainly private office) care. They also provide direct care to hospitalized persons. In the first case, the physician's office practice can be regarded as a firm. In the second case, Michael Redisch and I have taken the view that the typical hospital might usefully be viewed as a firm run by and for physicians. (See "The Not-for-Profit Hospital as a Physicians' Cooperative," *American Economic Review*, Vol. 63, No. 1, March 1973, p. 87.)

My work involves investigating two specific aspects of physician effects, and a more general model that attempts to incorporate a number of the effects. I have completed a working paper that focuses on the question of the effect of physician inputs on the production of hospital output. This paper presents estimates of hospital production functions in which measures of physician inputs are used. I selected a sample of rural midwestern counties containing just one short-term general hospital with more than fifty beds and collected data on number of cases treated and hospital inputs for the period 1966–1972. I divided hospitals into subsamples of more than or less than 100 beds and of not-for-profit or governmental control. I measured physician input (1) by the number of patient-care physicians practicing in the county, and (2) by the number of physicians on

the hospital's active medical staff. I measured output by the number of cases treated. Although no explicit information on diagnostic mix is available, the similarity of the populations served make it likely that the mix does not vary widely across hospitals. Using a Cobb-Douglas production function, and the first measure of physician input, I found that physicians *did* have a positive effect on hospital productivity, with an output elasticity of approximately 15 percent for all subsamples. The second measure yields an output elasticity of 22 percent for hospitals of over 100 beds. If national average physician net incomes and proportion of hospital visits in total visits are used to obtain a measure of the opportunity cost of physician hospital time, the estimates suggest that there is overuse of hospital-employed inputs relative to physician inputs. This could occur for one or both of two reasons. It could be that the group of physicians who are hypothesized to control the hospital find that their real and money incomes can be increased (even if total costs of care are increased) by substituting hospital inputs for their own when the cost of hospital-employed inputs is covered by cost-based hospitalization insurance. It could also be that the group cannot fully control the attempts by individual physicians to substitute hospital inputs for their own.

The main way in which physicians increase hospital productivity is by reducing length of stay per case treated. When length of stay is included in the production function as a "characteristic" of output, physician output elasticity falls by two-thirds.

The second specific kind of physician effect I am investigating is demand creation. In particular, I am looking at the differences in the effects of physician and hospital input availability (price and other demand parameters held constant) on the use of medical care for different kinds of persons, different kinds of care, different types of physicians, and different illnesses or complaints. The underlying theoretical model is one in which price to the physician is sticky, but in which he can affect use by altering the content of information he provides. This model predicts that consumer responses will be different depending on the initial amount of information they receive and

the confidence they have in that information, the amount of information physicians provide before use occurs, and the uncertainty of the medical situation. It also predicts that the way in which physicians manipulate information will depend on their incomes and the price they receive. The model will be developed further, with a view toward determining what empirically observable variables are suitable proxies for the theoretical concepts, and toward devising ways of distinguishing the "information manipulation" approach from alternative theories of the availability effect, especially the idea that the effect is attributable to chronic (but variable) excess demand or nonprice rationing. The data to be used consist of information on patients' characteristics, illnesses, and use of care from the 1970 Health Interview Survey (a total of 116,466 observations), combined with information from other sources on the availability of various types of hospital and physician inputs.

A third part of my work involves specification and estimation of a complete model of the demand for and supply of hospital care using state-aggregated data. In addition to using a number of different measures of the availability of different types of physicians, this model explicitly treats the user price for in-hospital *physician* services as a component of the total price the patient pays. Because the hospital bill is likely to vary more with length of stay than does the physician's bill, it is possible to encounter different prices for admissions and days of stay and to estimate demand equations for both. On the supply side, I will specify a model of physician-utility-maximizing price-making hospitals that will include some measures of the degree of competition among hospitals and physicians. I also will investigate the effect of hospital *and* physician fee insurance coverages on hospital and physician prices.

<div align="right">Mark V. Pauly</div>

Utilization of Surgical Manpower

Our recent study of the operative work loads of a population of general surgeons in a prepaid group practice revealed that the mean weekly operative work load in that setting was 9.2 hernia equivalents (HE).[1] This mean weekly work load was more than twice the mean weekly work load found in a population of nineteen general surgeons in suburban community practice in the New York metropolitan area (4.2 HE/week) and approximated an informal standard elaborated in a previous study for an active yet not overburdening surgical work load (10 HE/week).[2] A subsequent time-motion study of this latter population of general surgeons revealed a mean seven-day total working week, including evening activities, of 44.3 hours, of which 38.5 hours were devoted to professional activities.[3] To determine the amount of and the nature of professional time associated with the operative work loads of the prepaid population of general surgeons, their time utilization was investigated through a combination of time-motion and self-reported time-log techniques.

The seven general surgeons had a highly structured daily rotation to enable them to share the burdens of office work, operating, surgical assisting, and consultation as evenly as possible each week. The schedule functioned in such a way that each day of the forty-nine surgeon-day week was designated by a specific principal task and the task days were then allocated to each surgeon in numbers consistent with an even distribution of tasks. The days were divided into operating days, assisting days, office days, weekday consulting days, weekend consulting days, and regular weekend days.

Because resources restricted us to only two and one-half weeks for the time-motion analysis in the fall of a recent year, we decided to sample heavily from the most frequently occurring weekdays, six operating and six office days, and to fill out the sample with one observation of the next most frequently occurring weekday, a consulting day. Specific days for observation were selected randomly, not repeating the same surgeon for the same type of day. Each surgeon

1. E. F. X. Hughes; E. M. Lewit, R. N. Watkins, and R. Handschin, "Utilization of Surgical Manpower in a Prepaid Group Practice," *New England Journal of Medicine*, Vol. 291, October 10, 1974.

2. E. F. X. Hughes, V. R. Fuchs, J. E. Jacoby, and E. M. Lewit, "Surgical Work Loads in a Community Practice," *Surgery*, Vol. 71, March 1972.

3. E. F. X. Hughes, E. M. Lewit, and F. V. Lorenzo, "Time Utilization of a Population of General Surgeons in Community Practice," *Surgery*, Vol. 77, March 1975.

was notified of his specific day for observation only twenty-four hours before that observation was to begin. Each surgeon was met by the observer at the very beginning of his professional day and then accompanied by the observer until the end of all scheduled professional activities on that day. The methods used to collect the data were virtually identical to those utilized in our previous time-motion study.[4] In addition to recording the surgeon's activities on the day of observation, the observer queried the surgeon about the nature and duration of any professional activities during the preceding evening and, at the end of the first day of observation, gave each surgeon a structured log form in which to record his professional activities during both the daytime and evening hours for the next six consecutive days. To facilitate both the ease and the accuracy of self-recording, these log forms requested information on time utilization in pre-defined, broad categories such as operating, office activities, and rounds in units of fifteen minutes. Thus, data were collected on all the professional activities of the surgeons for a seven-day week.

4. Ibid.

To validate the accuracy of the self-recorded data, evening activities and daytime activities were aggregated separately and the time reported for specific daytime activities was compared with the time observed for the same activities on the observed days. A comparison of both the duration of the entire work day and of the individual activities for the self-reported days and on the observed days revealed that for all the major components of the working day—e.g., office activities, rounds, operating room time, administrative activities, and meals—not only was there no statistically significant difference between the mean times reported and the mean times observed but often these times differed only by a matter of minutes. On the basis of this validation, a standardized seven-day mean working week was calculated for this population of surgeons and evening time at professional activities was also calculated and added to the mean standardized seven-day week to yield a total seven-day working week.

The mean standardized seven-day working week, excluding evenings, was found to be 56.2 hours (Table II-16). This working week was

TABLE II-16

Comparison of the Distribution of Time in Mean Working Week by Type
of Activity of Seven General Surgeons in a Prepaid Group Practice
With Nineteen General Surgeons in Community Practice

	Mean Time per Activity per Week for Prepaid Group Practice (1)	Percent of Week	Mean Time per Activity per Week for Community Practice (2)	Percent of Week	Ratio Between (1) and (2)
Office	14:50	26.3	11:38	32.4	1.28
Rounds	17:56	31.9	3:49	10.6	4.70
Operating time					
As primary surgeon	12:54	22.9	6:15	17.4	2.06
As assisting surgeon	1:31	2.7	2:02	5.7	0.75
	14:25	25.6	8:17	23.1	1.74
Administration	2:34	4.5	1:02	2.9	2.48
Other direct patient care	:10	0.3	1:19	3.4	0.13
Other indirect patient care	:52	1.5	1:12	3.3	0.72
Meals	2:44	4.9	1:28	4.8	1.86
Personal	:57	1.7	1:59	5.5	0.48
Continuing education	1:17	2.2	:21	1.0	3.67
External travel	:00	0.0	3:13	9.0	0.00
Miscellaneous	:32	0.9	1:38	4.6	0.33
Total	56:13	100.0	35:55	100.0	1.57

spent entirely in the hospital of the prepaid plan. Over 85 percent of this mean week was spent either in office activities, on rounds, or in the operating room. Out-of-office administrative activities comprised 5 percent of the week. A small amount of additional administrative activity was observed in the surgeons' offices, which if it were to occur more regularly, would raise the proportion of overall administrative activities to about 6 percent of the week. Another 3 percent of the week was devoted to a variety of miscellaneous activities, including continuing education.

The mean duration of professional activities in an evening was 57.6 minutes. Sixty-one percent of this time was devoted to reading journals and 21 percent to administrative activities. The remaining 18 percent of evening activities (10.5 minutes) consisted of direct and indirect patient care. Most of this time was spent seeing hospitalized patients or operating on them. The median time devoted to each activity in the evenings was zero minutes, indicating that on at least half of the studied evenings, each of the activities did not occur. If seven evenings a week of such activities had occurred in the prepaid group practice, a total of 6.7 evening hours per week would have been devoted to professional activities. Adding this professional evening time to the mean standardized seven-day working week results in a total working week of 62.9 hours.

Comparison of the mean standardized seven-day working week with that observed for the community surgeons previously studied reveals some interesting contrasts (Table II-16). Most noticeable is the fact that the mean standardized working week of the general surgeons in the prepaid group practice exceeded that of the community surgeons by twenty hours, a difference of 57 percent.

The surgeons in the prepaid group practice spent 28 percent more time in office activities, 74 percent more time in operative activities, and almost 500 percent more time on rounds. This last finding is attributable to two factors. First, the surgeons in the prepaid group saw more individual patients per day on rounds than the surgeons in the community, 8.0 vs. 5.0, consistent with their higher operative work loads.

Second, in addition to morning rounds, they also made afternoon rounds on almost half their patients. In the community, the surgeons almost exclusively made only morning rounds.

Although the surgeons in the prepaid group practice spent over twice as much time as primary surgeons compared to the surgeons in the community (consistent with the doubling of their operative work loads), they spent approximately 25 percent less time as assisting surgeons. In fact, had they assisted at the same rate relative to their primary work loads in the prepaid group as in the community, each surgeon would have had to spend an additional two and one-half hours as an assisting surgeon per week. This economy in the utilization of the general surgeons' time in the prepaid group was accomplished through the use of operating room technicians as first assistants on cases judged not to require the skill of a general surgeon.

A major qualitative and quantitative difference between the mean working weeks in the two settings is the absence of a number of activities in the weeks of prepaid group surgeons that appear in the weeks of the community surgeons. Most salient of these is 3.2 hours of "external travel" in the week of the community surgeons. This external travel in the community practice was, for the most part, consumed during the working day in driving from hospital to hospital, from hospital to office, and on the few house calls and other ambulatory care activities, such as industrial plant physicals, in which the community surgeons engaged. This travel did not occur within the practices of the prepaid group surgeons because their offices were located within the hospital in which they practiced and the scope of their practice was limited to patients either hospitalized in or appearing for ambulatory care to that facility. Associated with the 3.2 hours of external travel in the week of the community surgeons was an additional 1.3 hours of "other direct patient care" that was delivered in the variety of non-hospital and non-office locations. Much of this care was not surgical in nature.

In addition to collecting data on the time utilization of the surgeons, data were also collected on the thirteen days of observation on

all of the surgeons' encounters with patients. On the thirteen days of observation, the surgeons in the prepaid group saw 112 patients in their offices. All but two of these patients (98.2 percent) were judged to have a surgical problem. In community practice, 77 percent of the patients were judged to have a surgical problem. This finding would tend to suggest that the general surgeons in the prepaid group were further economizing on the utilization of their surgical skills by treating within their office case load a much smaller proportion of non-surgical patients.

Thus, the surgeons in the prepaid group practice were able to maintain an operative work load double that found in the community practice without doubling the amount of professional time worked. Economies in the utilization of their time would appear to stem mainly from geographic and specialty restrictions on the scope of their work and from the utilization of paraprofessionals as operating room technicians.

Studies are also continuing on (1) general surgeons in an academic milieu, (2) ophthalmologic surgeons in community practice, (3) operating room technicians in the above prepaid group practice, and (4) the rates of operative procedure in the prepaid group. Dr. Richard N. Watkins, now with the Group Health Cooperative of Puget Sound, served as a collaborator in the time-motion study. We are receiving expert research assistance from Donald Wright.

Edward F. X. Hughes
Eugene M. Lewit

Economic Aspects of the Practice of Internal Medicine

During my year at the National Bureau, I will focus on the variations in cost generated by internists while treating patients with similar illnesses. My main questions are (1) "How much cost variation is there among different internists treating the same illnesses?" (2) "How much variation is there in the mean cost of treating patients with the same illnesses by general internists versus general practitioners or subspecialists?" (and if I find a wide variation in cost) then (3) "What are the determinants of

these differences?" These determinants at present fall into four broad categories: (1) the training of the physician, (2) the personal characteristics of the physician, (3) the organizational background of his or her practice, and (4) the financial incentives he or she faces.

The last two questions are particularly important since the old controversy between "general internal medicine" versus "subspecialty" in the training of internists has flared up recently with the introduction of the new "family medicine" programs. The determinants of total cost per illness that I will be looking at are: the physician's fee, the number of consultations, the number of laboratory tests, the amount of drugs, the use of auxiliary services (i.e., physiotherapy, dieticians, etc.) and the number of hospital days. The physician's propensity to hospitalize will probably be the most significant variable in terms of cost generation. One recent study suggests that I might find a wide variation in physicians' behavior since it found a seventeen-fold variation in cost generated from laboratory use by thirty-three internists handling similar patients.

The first step in my study will be to choose tracer illnesses and to develop criteria to standardize for the level of complexity of each illness. As a pilot study, I will compare behavior among rheumatologists treating patients with rheumatoid arthritis of similar complexity at the Stanford Medical Center. The second step will be to compare physicians of different training and in different settings. If I find a wide variation in cost for treating similar illnesses standardized for complexity level, the next question to consider would be the degree to which this difference in cost is justified by a possible difference in terms of quality of the output—that is, improvement in the patients' condition.

Claire Bombardier

The Supply and Demand for Nursing Home Care

There has been considerable public recognition of the rising proportion of the nation's GNP devoted to health care. An important component of health care is services provided by nursing homes. In spite of the increasing proportion of

health expenditures devoted to nursing home care—an increase from 1.5 percent in 1950 to 4.4 percent in 1971—this sector has received little attention from economists. On the other hand, periodic scandals concerning adequacy of care generate public concern and sometimes new regulatory legislation.

This study explores the relationship between the utilization of nursing home care by the aged and economic, demographic, and regulatory variables. The model is developed for a cross-sectional analysis, and the equations are estimated with Standard Metropolitan Statistical Areas (SMSAs) as the unit of observation. Implications develop which also help explain the time series growth of nursing home care.

The theory emphasizes that there are four factors that tend to raise the demand for nursing home care: a lower price of such care; a higher cost of alternative care; a higher income of families in the SMSA; and poorer wealth of the aged population. One measure of the cost of alternative care is the attractiveness of the labor market to adult, nonaged, married women—that is, the "daughters" of the aged. This attractiveness is measured by their labor force participation rate.

The long-run supply curve is hypothesized to be perfectly elastic, but to rise as the cost of factor inputs increases, particularly the wages of nursing aides, and as the quality of care improves. Since a very large proportion of nursing homes are owned or operated by physicians, a physician supply variable is included.

Preliminary estimates support the hypotheses about the effects of particular variables and the usefulness of the overall approach. The analysis suggests that the secular growth in nursing home utilization rates by the aged is related to the secular rise in income, the increased opportunities in the labor force for adult (nonaged) women, and the rising public subsidies for nursing home care. Recently acquired data on regulations will provide an opportunity to examine in greater detail the role of public policy in the nursing home sector.

Barry R. Chiswick

The Economics of the Optometry Profession

I am presently working on two studies in the economics of optometry. One study analyzes the production of optometric services in fee for service for profit practices. Interest in the production processes of such practices has grown in recent years because of the concern over the rapid rise in expenditures for health services and because of the alleged shortage of physicians and other primary health professionals. Studies of physician practices have shown that physicians may not be adequately organizing the production of their office-based services. In particular, physicians appear to be underemploying auxiliary manpower in the production process. One researcher concluded, for example, that the average American physician could employ profitably twice the number of assistants as he presently utilizes and by so doing, increase his hourly rate of output by 25 percent. If the results of these studies are correct, a substantial portion of the present inflation in the price of physician services and of the alleged shortage of health services could be avoided if physicians improved their entrepreneurial performance.

A major purpose of my analysis is to provide further evidence on the entrepreneurial performance of primary health professionals in fee for service for profit health practices. Preliminary results indicate that optometrists may be underemploying aides and other inputs in the production process. Actual input levels among optometrists are substantially less than the optimal input levels implied by production function estimates and the optometrists' opportunity cost of time.

The production function estimates are also used to examine the productive efficiency of different inputs and the scale economies that characterize optometric services. The data base is the 1964 American Optometric Association National Economic Survey. In this mail survey, 4,700 practicing optometrists provided data on the annual output of their practices (visual examinations and eyeglasses provided) and on their use of productive inputs (capital, office space, aides, and own time).

In the second study I specify and estimate a market model for optometric services in the United States. The model consists of three equations and one identity that incorporate four endogenous variables. The first of the three

equations is a demand equation for optometric services. The final two equations describe the supply of optometric services and consist of a location equation and a workload equation. The four endogenous variables are the quantity of services demanded, price, the per capita number of optometrists, and the quantity of services provided per optometrist (workload). This model is estimated across states, using primarily 1968 data.

The estimation of the market model makes it possible to examine the causes of interstate variation in the demand for optometric services, including the roles of price, income, education, and competing eye professionals (ophthalmologists and opticians). The effect of freedom to advertise on demand is also determined, because advertising by optometrists is restricted in some states and not in others. On the supply side the importance of price, average workloads, and the place of professional schooling on the location decision of the optometrist is investigated, as is the effect of state licensing requirements on interstate migration by optometrists. The estimated workload equation shows how optometrists adjust their workloads in response to changes in the price they receive for their services.

Douglas C. Coate

Experience and the Demand for Healthy Infants

During the past year, I have continued my research into the relationships among the demand for children, experience with previous pregnancies, and the results of prenatal care on the outcomes of individual pregnancy and aggregate pregnancy loss rates. My primary emphasis has been on the empirical investigation of some of the concepts of household behavior with regard to childbearing that I am developing within the context of a household decision-making model. Household decisions, based on previous experience regarding both the demand for additional pregnancies and for care during a particular pregnancy, are being examined. In addition, the joint, household-physician prenatal care process is being examined both from the perspective of the behavioral consequences

of experience and of variations in pregnancy outcomes resulting from differences in the intensity of care provided.

A simple theoretical model that I have developed suggests that the effect on the demand for children and, hence, pregnancies that vary in individual reproductive efficiency will very much depend on the price elasticity of the demand for children. The most important prediction this model makes is that for "reasonable" values of the price elasticity, a perceived fall in reproductive efficiency will lower the demand for surviving children (since they are more costly) but increase the demand for pregnancies since more are required per survivor. This implies that in measuring prenatal death rates for large population groups, such as nations or states, those members of the population whose reproductive efficiency is low will be more heavily represented because of their more frequent pregnancies. An interesting finding along these lines is that the measured mortality rates for a given population group will depend not only on the mean biological efficiency for the group but on the higher moments of the distribution of efficiency within the group.

I have investigated this hypothesis empirically by measuring the effect of differences in the distributions of education of females of child-bearing age, a correlate of reproductive efficiency, on infant mortality rates across SMSAs in the U.S. for rates centered on 1960. The results for both blacks and whites, and for both neonatal and post-neonatal death rates indicate that the second moment of the distribution (variance) particularly is of substantial importance in explaining inter-SMSA differences in death rates. The moments are particularly valuable in explaining variations in neonatal death rates—by far the largest component of infant death rates and an area not well explained by variations in the mean alone.

I have also been examining the course of pregnancies as a biological production process wherein inputs of market goods, such as medical care, and household inputs are combined within the mother's body to produce the resultant child. In addition to influencing the decision to attempt additional pregnancies, the sequential nature of the childbearing process

allows the household and physicians to learn about a mother's own biological production function. I have estimated demand and production equations for pregnancy outcomes using data on the 1970 New York City birth cohort (including pregnancies that ended in both live births and stillbirths). In this context, I have viewed a pregnancy as a sequential production process wherein prior information as well as parental experience during the pregnancy and other parental characteristics all impinge on the demand for and utilization of care as well as pregnancy outcomes.

I have utilized length of interval between the woman's last menstrual period and the first prenatal visit and the number of prenatal visits as indices of prenatal care. Clearly, the latter is dependent on the former; moreover, the length of the first visit interval is totally a household decision whereas the extent of care once the process has been initiated results from a joint household-physician decision process. For legitimate births, the first visit interval appears to be negatively correlated with maternal age, father's education (a proxy for permanent income), and the experiencing of prior pregnancy failures. Increasing the number of live children in the home lengthens the first visit interval. First-visit intervals for illegitimate births do not seem to be systematically related to any particular parameter. The number of prenatal visits for most pregnancies seems to be largely a result of the length of the first-visit interval and the obstetrical protocol for prenatal monitoring. Thus, regardless of race or legitimacy status, a mother who begins care during the second trimester of pregnancy will make one less visit than the mother who began during the first trimester, and a mother beginning during the third trimester will make three less visits. Older women and women experiencing first births also seem to make more visits. The number of live children in the home is negatively correlated with number of visits.

I have examined as measures of pregnancy outcome birth weight and the Apgar Score at one and five minutes after birth. The general impression created by these sets of regressions for all race and legitimacy groups is that experience tends to repeat itself. Lower birth weights

and Apgar Scores are associated with a history of previous pregnancy loss whereas number of live children in the home is associated with higher values. First children tend to fare more poorly—perhaps because of a lack of pregnancy experience; the amount of prenatal care as measured by the number of visits is associated with more favorable outcomes. It is interesting that, within the sequential pregnancy process system of equations that have been estimated, parental factors such as education of either parent or maternal age seem to have little independent effect on these measures of birth results.

Over the coming year, I intend to examine empirically the factors involved in infant, prenatal, neonatal, and post-neonatal mortality in the same sequential manner—that is to say, with birth weight or Apgar Scores held constant. I will be particularly interested in measuring the effect of special hospital care facilities on the survival of high-risk infants as well as the environmental effects on post-neonatal survival of such household factors as parental education and family size.

Eugene M. Lewit

Abortion and Fertility in New York City

I have been continuing work on my study of reproductive behavior among New York City residents before and after the legalization of abortion. The empirical analysis is based on vital records and census summary statistics for 1.7 million women residents in 296 geographic areas within the city. Last year in this space I reported on my findings concerning the quality of contraception practiced by the aborting population and the effect of abortion legalization on the citywide fertility rate. The univariate analysis of abortion demand described at that time has since been written up and was published by *Family Planning Perspectives* in its May-June 1975 issue as "The Incidence of Legal Abortion Among New York City Residents: An Analysis by Socioeconomic and Demographic Characteristics."

In the past year I have investigated the interarea differences in abortion demand by means of ordinary least squares multiple regressions. Of

the nine independent variables simultaneously considered, female labor force participation, the percentage of blacks in the population, the percentage of Puerto Ricans, and the pre-legalization level of fertility were each found to have highly significant positive associations with the total legal abortion rate, whereas marital status and the proportion of children in parochial school each showed a very strong inverse relationship with abortion demand. To a lesser degree, female education was also negatively associated with the abortion rate. Neither income nor welfare status explained any significant portion of the variance in abortion rates unaccounted for by the other seven variables. The coefficient of the race variable indicated that differences in socioeconomic characteristics were not able to account for any of the interracial differential in abortion demand (the lifetime-equivalent abortion rate among black women being 1.80, as compared with 0.71 abortions per life among white non-Puerto Ricans). Separate abortion demand equations estimated for blacks and for non-Puerto Rican whites from race-specific data demonstrated that coefficient differences (indicative of the differential responsiveness of abortion demand to the independent variables) were similarly unable to explain the disparity in mean abortion rates. Because the incidence of unwanted pregnancy may have been substantially higher among blacks than whites, the results do not necessarily imply that black women were more likely to abort their unwanted pregnancies than were their white counterparts. There clearly was, however, a much heavier reliance among blacks than whites on abortion compared to other methods of fertility control. The higher levels of both fertility and abortion demand among blacks suggest that the number of abortions obtained per birth averted was approximately three times as great in that population as in the white non-Puerto Rican group.

Area data on fertility in the post-legalization (1971–1972) period were released by the city in the summer of 1974. The analysis of these, now underway, will complete my study. The fertility statistics are being used first, to test alternate specifications of the economic model of fertility on a population with ready access to legal abortion and second, to examine the effect of abortion legalization on fertility differentials. Preliminary results from these investigations are summarized below.

1. Two stage least squares multiple regressions were run to test a variant of the Willis model of fertility, wherein the demand for wanted children is an increasing function of income and a decreasing function of the "price" of children.[1] Price variations in that model are theorized to result from differences in the quantity of resources invested in each child (child "quality") and from the opportunity cost of maternal time. The market wage rate is thought to represent the value of time for working women, whereas income raises the opportunity cost of time for non-working women (by making time for consumption scarce relative to the availability of market goods and services). Since unwanted fertility was almost certainly less prevalent among New Yorkers in this post-legalization period than in previous study populations, the New York data are ideally suited to a test of the above hypotheses. An exogenous income variable was constructed by excluding female earnings and welfare payments from the income aggregate (each of these being closely dependent on fertility). Child quality, endogenous because of its inverse dependence on fertility, was measured by the proportion of school-age children attending private schools. The average weekly wage of women workers was multiplied by the total female labor force participation rate to yield a price of time variable reflective of working women and duly weighted by their preponderance in the observation area. Similarly, income multiplied by the extent of female non-participation in the labor force yielded a price of time variable reflective of the non-working segment of the female population and weighted accordingly. Because wage rates rise with experience in the labor force, and female labor force participation is itself an inverse function of fertility, each of the time-price variables was endogenous. The resulting fertility demand equation was successful in explaining 77 percent of the inter-area variance in total

1. Robert J. Willis, "A New Approach to the Economic Theory of Fertility Behavior," *Journal of Political Economy*, Vol. 81, No. 2, Part II, March/April 1973.

fertility rates. Each of the four independent variables was significant at the 99.9 percent level and bore the expected sign. Other specifications of the economic model of fertility will be tested in future research.

2. The city-wide decline in total fertility rates immediately following the legalization of abortion was heaviest among blacks and among the poor. Prior to legalization, black women were averaging 0.70 more births per life than whites, at prevailing age-specific fertility rates. After legalization the black fertility rate fell to the replacement level, 2.11, and the black-white fertility differential fell to 0.27. Within racial groups and across the entire population, the long-standing inverse association of fertility and income was moderated subsequent to the legalization of abortion. However, although unwanted births were almost certainly few in number (since *total* fertility was at a rate of only 1.95 births per woman per life), the historical relationship between fertility and income showed no signs of reversing.

<div align="right">Marcia J. Kramer</div>

Population and Family Economics

Introduction

The research program in population and family economics has been supported in the past year by grants from the Ford Foundation and the Center for Population Research, National Institute of Child Health and Human Development, DHEW. The program director is Robert J. Willis.

In the past year, Warren Sanderson has completed a study of the aggregate time series of U.S. age- and parity-specific birth probabilities from 1920 to 1966. The manuscript has received staff review and a final revision will be completed soon. Sanderson has begun a new study of time-series marriage and fertility that is described below in his report.

The program has continued to emphasize studies of the microeconomic determinants of family demographic behavior over the life cycle and relationships between this behavior and other aspects of family decision-making. The dramatic increase in the divorce rate in recent years provides a challenge to the capacity of economic theories of family behavior to help explain important social phenomena. In their report, Gary S. Becker, Elisabeth Landes, and Robert T. Michael report their progress on a rather extensive project that attempts to explain cross-sectional and time series variations in marital instability within an economic framework. A paper that examines marital instability using cross-sectional data from the 1967 Survey of Economic Opportunity and longitudinal data from the Terman sample is being drafted. In their future research, they plan to see if cross-sectional studies of divorce can help explain time series patterns of marital instability.

The increasing availability of retrospective and prospective longitudinal data promises to greatly enhance our understanding of interactions between family demographic and economic behavior over the life cycle. However, conventional econometric techniques are often unsuited to the study of the life-cycle pattern of discrete events such as marriage, divorce, births, and labor force participation. James J. Heckman and Robert J. Willis report on their research into new statistical methods for use in panel data and describe results of applications of these methods to data on contraception and fertility and sequential labor force participation by married women.

Understanding the role of the family in the nurture and care of children is crucial to an understanding of the means by which society's stock of human capital is maintained or increased across successive generations. Arleen Leibowitz has continued her studies of the effects of parental investments of time and goods on the health and educational achievement of children. Although it seems clear that parents in the contemporary United States make net bequests or transfers to their children largely in the form of human capital, it has long been argued that parents in less developed countries rely on transfers from their children for security in old age and ill health. Dov Chernichovsky, a pre-doctoral fellow in the population program, has formalized these arguments in a model of fertility behavior that emphasizes the investment motive for fertility. He has tested some of the hypotheses derived from this model with household survey data from two villages in India and

plans to extend his empirical work with survey data from other less developed countries.

Although the bulk of the work in the NBER population program will continue to be devoted to the analysis of demographic behavior in the advanced countries, particularly the United States, serious consideration is being given to the initiation of studies of family economic and demographic behavior in the less developed countries that will utilize bodies of household data that are now becoming available.

Robert J. Willis

The Analysis on Time Series Fertility Variations in the United States

One long-term interest of the Population Project at the NBER has been to gain some understanding of the processes underlying fertility variations over time in the United States. In the past year, I have completed one study on this theme and moved on to another. The completed study measures and analyzes the age- and parity-specific birth probabilities of native white women born in the twentieth century. The manuscript has been through staff review and a final revised version has been completed. Among the findings of this study is that the baby boom peak in the total fertility rate in 1957 is not a consistent peak in the birth probabilities. For example, second- through fourth-order births to women below the age of 30 tend to peak around 1960. Thus, attempting a behavioral explanation of why aggregate fertility measures peaked in 1957 could be quite hazardous. Another finding is that the timing of postwar fertility movements has been significantly influenced by systematic changes in birth probabilities across cohorts even when the effect of current year influences is taken into account. The manuscript contains a discussion of the relationship of the changes across cohorts and the Easterlin hypothesis.

The new study of time series variations in fertility in the United States grows out of the last study and combines recent developments in both demography and economics. Within the last four years demographers have published parameterizations of distributions of the age at first marriage and of distributions of marital fertility by duration of and age at marriage. That

work has shown that not only do the separate parameterizations fit a wide variety of observed distributions well, but also they may be combined into a satisfactory description of age-specific fertility rates. The functional forms used by demographers allow us to distinguish forces acting on fertility via marriage rates and ages at marriage from those acting directly on marital fertility and to distinguish between cohort and current year influences on both the age at marriage and the marital fertility distributions. Furthermore, changes in the availability of contraceptive techniques can be explicitly taken into account in this framework. Work has begun on estimating the parameters of several of the distributions. I am using economic theories of marriage and fertility to explain both the behavior of the parameters over time and the deviations of observed behavior from the predicted behavior.

Another project in which I am engaged (with Professor Paul David of Stanford University) is the analysis of a set of questionnaires administered to well-educated women around 1900. The data in these questionnaires include observations on the fertility histories, contraceptive practices, and sexual habits of the respondents. To our knowledge, these are the earliest individual data collected on these important topics. Preliminary work indicates that this data will be valuable in tracing how contraceptive practices changed over time in the United States.

Warren C. Sanderson

Marital Instability

We are continuing our study of marital dissolution that was described briefly in last year's *Annual Report*. The theoretical analysis uses elements of human capital theory, search theory, and Becker's recent theory of marriage to explain and predict cross-sectional differences and time series trends and fluctuations in rates of marital instability. We expect to complete soon our analysis of two cross-sectional data sets—the 1967 Survey of Economic Opportunity data with nearly 20,000 men and women, and the Terman sample of some 1,500 high-IQ men and women.

Since in last year's *Annual Report* we summarized a few of the results from the theoretical

analysis and some of the findings from the Terman sample, we will report here a few preliminary results from the SEO data. Our analysis focuses attention on the rates of marital dissolution during specific time-duration intervals following marriage. For example, we consider marital dissolution within the first thirty months of marriage. In one subsample of some 8,200 white males for whom retrospective information is available in the SEO survey, about 2.3 percent were divorced or separated during the first thirty months following the date of their first marriage. We relate this measure of their marital instability to several characteristics of the men—their birth cohort, age at marriage, schooling level, their earnings in the survey year, and our estimate of the difference between their actual earnings and what they might have anticipated their earnings to be. This analysis suggests that higher levels of earnings are associated with higher marital stability. For example, using the elasticity estimate implied by one of our estimating equations, a 50 percent increase in the earnings at the mean (e.g., from $7,200 to $10,800) is associated with a reduction in the probability of marital dissolution over the first thirty months of marriage from 2.3 percent to about 2.1 percent.

Although higher earnings are associated with more stable marriages, it also appears that men whose earnings deviate relatively more from their predicted earnings are more likely to have unstable first marriages. Positive deviations as well as negative deviations increase the likelihood of instability. This may explain why the negative relationship between marital instability and income disappears at very high levels of income. Individuals with very high as well as very low levels of income are more likely to deviate from their predicted levels of income.

As has been generally observed in studies of marital instability, age at marriage appears to be an important predictor of marital instability—by one of our estimates, the elasticity of the probability of marital instability in the first thirty months of marriage with respect to age at marriage is about −2.3 at the mean. That is, an increase in the age at marriage from say age 21 to age 26 would lower the probability of dissolution during that thirty month period from about 2.5 percent to about 1.1 percent. Above an age at marriage

of about age 30, however, further increases in the age at marriage tend to be associated with *increases* in the probability of marital dissolution.

In addition to the analysis of the factors associated with marital dissolution in the first thirty months of marriage, we also considered the impact of a set of explanatory variables on the probability of dissolution in the second thirty months of marriage. This equation yields estimates of the conditional probability of instability during the thirty-first to sixtieth month of marriage, conditional upon an initial thirty months of marital stability. We are analyzing each successive thirty month time interval for the first 15 years of marriage, and longer intervals for an additional 10 year period.

The analysis is also performed for the sample of about 10,000 ever-married women in the 1967 SEO data set. Here, one of the two more interesting results to date is the apparent deterrent effect of young children (under age 6) on the probability of marital dissolution. That is, we include in our estimating equation for the probability of dissolution during, say, the 90th to 119th month of marriage the number of children of specific age-intervals in the household at the beginning of the 90th month of marriage.

The age distribution of children is an important predictor of the likelihood of marital dissolution throughout the first twenty years of marriage. Youngest children appear to have the strongest negative effect on separation and divorce, whereas children over age seventeen have no significant effect at all. After about twenty years of marriage the inhibiting effect even of young children on marital instability is no longer apparent in the regressions.

The other interesting result in the analysis of women's marital instability is the positive effect on marital dissolution of a variable reflecting a premarital conception. While the effect is strongest in the first thirty months of marriage, this effect persists at all marriage durations!

A first draft of our paper, setting out the theory and applying it in detail to the SEO and Terman data, and referring also to the empirical findings of others, was completed during the summer of 1975. Subsequent work on the time series data is expected to take about a year. In-

formal drafts of our paper have been presented at the Western Economic Association meetings in June 1974 and the Population Association of America meetings in April 1975.

Gary S. Becker
Elisabeth Landes
Robert T. Michael

Quantal Responses in Panel Data: Contraception, Fertility, and Female Labor Force Participation

Many important aspects of household behavior involve choices among discrete alternatives or decisions that lead to discrete outcomes. Recognition of this fact has generated considerable discussion recently of statistical models such as the multivariate logistic model that are appropriate for the analysis of such "quantal response" problems in cross-sectional data.[1] Examples of such problems include the analysis of dichotomous choices such as labor force participation, polytomous choices such as choice of contraceptive technique, or the joint choice of two dichotomous or polytomous variables such as the joint decision to contracept and to participate in the labor force. (Notice that these joint variables may be represented as a polytomous variable with four categories: contracept and work, contracept and not work, etc.)

Important quantal response problems also arise in the study of life-cycle behavior with panel data. The timing or time path of discrete events or decisions such as leaving school, labor force participation, migration, marriage, divorce, births, and death provide examples of such problems. For a number of reasons, statistical models such as the multivariate logistic model that are appropriate to the analysis of quantal response problems in cross-sectional data are inappropriate in panel data.

One reason stems from the so-called "mover-stayer" or "heterogeneity" problem. Commonly, it is found in migration studies that individuals who have moved frequently in the past are more likely than others to move in the future and that

the probability (per unit of time) that an individual will move from a given location decreases the longer the individual has spent in that location. An explanation for this phenomenon is that the population is heterogeneous in the sense that some individuals have persistently higher propensities to move than others; that is, some are "movers" and others are "stayers." As time passes, stayers tend to become a larger fraction of the sample remaining in a given location. Hence, the conditional probability of moving appears to decline with duration of stay even if each individual's migration probability is constant. Similar patterns emerge from data on monthly probabilities of conception, labor force participation, marital instability, and so on. As we indicated in our report last year, heterogeneity presents a problem for the economist interested in the determinants of individual behavior because changes or differences in individual behavior tend to be confounded with changes in sample composition.

In a paper now being drafted, we present a generalization of the multivariate logistic model that may be applied to panel data in which selection probabilities are heterogeneous. We assume that selection probabilities follow a beta distribution in the case of a dichotomous variable such as labor force participation or, more generally, a Dirichlet distribution in the case of a polytomous variable such as the joint decision to contracept and to participate in the labor market.

The beta is a two-parameter distribution, $B(a,b)$, which ranges between zero and 1, and has mean $a/a+b$ where the parameters a and b must be positive. It is assumed that a and b are both functions of a vector of exogenous variables. To guarantee that a and b are both positive, we let $a = e^{\alpha x}$ and $b = e^{\beta x}$, where α and β are vectors of parameters and x is a vector of exogenous variables. Given this paramaterization, the mean selection probability in a given time period is

$$p = \frac{a}{a+b} = \frac{e^{\alpha x}}{e^{\alpha x} + e^{\beta x}} = \frac{1}{1 + e^{(\beta - \alpha)x}}$$

which is nothing more than a logistic function with a coefficient vector $\gamma = \beta - \alpha$. (A similar

1. See Daniel McFadden, "Quantal Choice Analysis: A Survey," Department of Economics, University of California, Berkeley, March 1974, for a survey of developments in this field and references to the literature.

parameterization of the Dirichlet distribution leads to a generalization of the multivariate logistic.) With cross-sectional data, β and α cannot be identified separately. Hence, the ordinary logistic function can be used to predict only the mean selection probability in the population as a function of the x's. However, with two or more observations on the same individual in panel data, both α and β can be identified and the entire distribution of selection probabilities can be estimated. Using these parameter estimates, we may determine the shape of the distribution of the selection probabilities across individuals. For example, if a and b are both less than 1, the distribution of probabilities will be U-shaped, with most individuals having probabilities near either zero or 1 and relatively few having probabilities near the mean of the group as a whole. In this case, the "mover-stayer" characterization of heterogeneity is fairly close to the mark. We may also predict the frequency of the occurrence of the event over time using the formula

$$P(j, k) = \frac{B(a + j, b + k)}{B(a, b)}$$

where the event occurs j periods and does not occur in k periods out of $t = j + k$ periods.

An application of the multivariate version of this model is reported in our paper with retrospective data from the 1965 National Fertility Study. We consider a group of women who practice contraception following the birth of their second child. In each month of the interval, a woman may decide to continue practicing contraception or decide to discontinue contraception and she may become pregnant or not. The joint occurrence of these events is then considered as a four-category polytomy. Using our estimates we found (1) that the mean

monthly probability of conception given contraception was 0.022, (2) that the mean monthly probability of conception given no contraception (i.e., after discontinuation) was 0.473, and (3) that the mean monthly probability of discontinuation of contraception was 0.0387. We also estimated the effects of husband's and wife's education and the age of the wife at the birth of the second child on these probabilities. One finding was that increases in husband's and wife's education increase the probability of discontinuation whereas increases in wife's age decreases this probability. This is consistent with the view that the proportion of couples attempting to terminate child bearing increases with the age of the wife and that more highly educated couples tend more frequently to contracept in order to space their children.

In a second paper that is also being drafted we have applied this statistical method to data on the sequential labor force participation of married women from the University of Michigan Panel on Income Dynamics. We find that the distribution of labor force participation probabilities is U-shaped; that is, most women either have a very low or a very high probability of participation and relatively few women have probabilities near the mean participation rate of the group as a whole. The model also has considerable predictive power, especially for predicting the probabilities that women work continuously or stay out of the labor force continuously, as is indicated in Table II-17.

We are also developing alternative econometric models for quantal response problems in panel data. For instance, it is possible that some of the variation in participation probabilities among women results from transactions costs in finding a job rather than differences in individual work propensities. To test this hypo-

TABLE II-17

	Year t	1967	1968	1969	1970	1971
Probability of working until year t	actual	.41	.35	.32	.28	.26
	predicted	.44	.36	.32	.29	.27
Probability of not working until year t	actual	.59	.50	.43	.39	.37
	predicted	.56	.47	.43	.40	.38

thesis, we need to allow the probability of work in one year to depend on the employment status of the women in the preceding year as well as on heterogeneity of probabilities among women, given employment status. We have specified such a model, but have not yet estimated it.

James J. Heckman
Robert J. Willis

Home Investments in the Health and Development of Children

Some (and perhaps much) of an individual's lifetime history of earnings and schooling depends on his experiences before he even begins school. Although economists generally regard such factors as ability as exogenous, it is possible to treat measured ability as being alterable by expenditure at home of time and goods by the family. I have completed a paper, "The Parental Bequest to Children" (NBER Working Paper No. 81), that formulates a model whereby parents derive utility from transferring resources to children as well as from their own consumption. Empirically, measured ability of children at ages 3 to 5 is increased by their parents' expenditures on them of time and goods. Evidence supports the hypothesis that abilities are related to the inputs of time and goods. Particular uses of time—for example, reading—are more productive of measured ability than others—such as watching T.V. with the child. Also, increased ability reduces the real cost of acquiring a given level of schooling. The amount of schooling demanded for their children by parents is related to this cost measure, as well as to family income.

The health of an adult is an asset that is partly determined in early childhood by economic decisions of his parents. The variation in inputs to child health is the topic of a second study, undertaken jointly with Bernard Friedman of Brown University. Using data from the Health Information Survey (1969) we find that the demand for physicians' services for preschool children with no chronic conditions is consistent with a "bequest" model like the one described above. Several empirical phenomena that we find in the data—such as the greater relative demand for physicians' services for young children by more highly educated mothers—indicate a "bunching" of expenditures in early childhood by parents desiring to increase investments in their children. A report on this work was given at the 1974 meetings of the Econometric Society and a paper, "The Bequest Motive in Human Investment and the Health Care of Children" is available.

Arleen Leibowitz

Fertility Behavior in Developing Economies: An Investment Approach

The model I have developed and its testing explore the behavioral consequences of investment-motivated fertility behavior in developing economies. These economies are masked by general lack of specialization, including the lack of organized capital markets (and institutions) to facilitate low-cost intertemporal transfers of consumption opportunities. In such an environment, children are assumed to function as a means to even out the parents' economic opportunities over the latter's life cycle.

Parents, by rearing children, forego current consumption opportunities, which are transformed into services from children at the time of the parents' retirement. Future income from offspring, which is a function of their own well-being, can be treated as a stochastic variable that depends on an underlying distribution of each child's survival probability (which can be generalized to include other relevant parameters).

In the first part of the model, children's mortality rates and their anticipated relative wages are assumed to be exogenous to the parents. Under this assumption, parents can determine their future income distribution by fertility only, ceteris paribus. In the second part, it is assumed that parents can also affect their future income distribution by investing in their children's health and education. An expected utility analysis is applied to determine how much is invested in each "asset."

The theoretical structure produces the following major implications:

1. An increase in parents' income during the child-bearing part of their life cycle will increase desired fertility.

2. Decreased child mortality or increased adult wages of children will increase the expected return to the parents per child. This will increase (decrease) the number of births if the price elasticity of demand for future consumption is greater than (less than) 1. It is plausible that continuous decreases in mortality or increases in wages will initially increase and later decrease fertility.

3. Development of institutions that secure future income will reduce desired fertility. This effect will be stronger if the institutions are financed by taxing income during the most productive part of the parents' life cycle.

4. Increasing real lending rates and reducing borrowing rates will reduce desired fertility.

5. Investments in children's health and edu-

cation are complementary; investment in health is a means to secure investment in education.

The model is tested on survey data of two Indian villages. It is apparent in both villages that the elderly are supported by their children and that children contribute to family income at ages as early as 11 to 15. The pure income effect on the demand for children and their education is positive. The demand elasticity for child services as revealed by the demand for survivors is less than unity.

Further investigation is to be undertaken to explore the explicit relationship between fertility and financial savings, since the two are key parameters in the macro analysis of economic growth.

Dov Chernichovsky

4. FINANCIAL AND INDUSTRIAL INSTITUTIONS AND PROCESSES

Financial Institutions and Processes

Introduction

The program of studies on the Effects of Inflation on Financial Markets, our main effort in the financial area during the last few years, is now nearing its conclusion, with several reports published and most of the others in manuscript form. Research has also continued on Lewellen's study of Individual Investor Portfolio Performance, which is exploiting an unusual set of data containing both demographic information and complete records of stock holdings and transactions of a substantial sample of individual investors.

Two new studies are reported on below: Sherman Maisel's examination of Information and Financial Institutions and Robert Shiller's study of Time-Series Analysis Applied to Interest Rate and Price Data, which is closely related to the subject of Sargent's work in the Effects of Inflation project, and has been conducted during Shiller's term as a Research Fellow at the Bureau. In addition, Donald Farrar reports on a conference, jointly sponsored with other organizations, on Regional Stock Exchanges in a Central Market System.

Several publications, in addition to those

mentioned in the separate reports below, were issued during the past year. One of these was "The Yield on Insured Residential Mortgages," by Anthony J. Curley and Jack Guttentag, the last report from the Study of Interest Rates, financed by the American Life Insurance Association, which appeared in *Explorations in Economic Research,* Vol. 1, No. 1, summer 1974. "The Impact of Monetary Policy on the Allocation of Bank Credit," by David Kresge, the final report from a study of banking structure supported partly by the American Bankers Association and the Federal Reserve Bank of Boston, was published in *Explorations in Economic Research,* Vol. 1, No. 2, fall 1974. This is a microeconomic study of the behavior of the commercial banking industry from 1965 to 1967.

Leo Troy's paper on "The Finances of American Labor Unions," which originated in the Bureau's study of Institutional Investors and Corporate Stock for the Securities and Exchange Commission, was published in *Explorations in Economic Research,* Vol. 2, No. 2, spring 1975.

Robert E. Lipsey

The Effects of Inflation on Financial Markets

This program, supported by a grant from the American Life Insurance Association, is now

nearing completion and the reports on the individual studies have either been published or are being prepared for publication. They cover the effects of inflation on stock prices, convertible and standard bond yields, household saving, and investment policies of major financial institutions.

The published studies are: Lester Taylor, "Price Expectations and Households' Demand for Financial Assets," *Explorations in Economic Research,* Vol. 1, No. 2, fall 1974; Phillip Cagan, "Common Stock Values and Inflation—The Historical Record of Many Countries," *National Bureau Reports,* Supplement 13, March 1974; Thomas Sargent, "Interest Rates and Prices in the Long Run," *Journal of Money, Credit and Banking,* February 1973; and John Lintner, "Inflation and Common Stock Prices in a Cyclical Context," in the 53rd *Annual Report* of the NBER, September 1973. In addition, Sargent has published several papers that are by-products of the present study, including "Rational Expectations, the Real Rate of Interest, and the Natural Rate of Unemployment," *Brookings Papers on Economic Activity,* 1973, No. 2; "The Fundamental Determinants of the Interest Rate: A Comment," *Review of Economics and Statistics,* August 1973; and (with Neil Wallace) "Rational Expectations and the Dynamics of Hyperinflations," *International Economic Review,* June 1973.

Sargent has also written and circulated, in addition to the above, an article summarizing his own and other recent work on the subject of inflation, expectations, and interest rates. In this review he discusses the reasons why Irving Fisher's long-standing proposition that nominal interest rates equal the real rate of interest plus the expected rate of inflation must be modified to take into account indirect effects of inflation on the real rate. Under most circumstances Fisher's proposition will hold for the long run, but this long run can in fact be very long indeed. Sargent also discusses some recent research which suggests that expectations of inflation, though subject to error, appear to be formed "rationally" in the sense of incorporating all the available information without significant lags or bias. The behavior of nominal interest rates in recent decades appears to reflect rational ex-

pectations to a much greater degree than was true formerly. This paper has been submitted to the Board of Directors.

Phillip Cagan

Investment Policies of Major Financial Institutions Under Inflationary Conditions

We have completed a draft on our study of the use of income participations (IPs) by major life insurance companies, savings banks, and other institutional investors, and has now been reviewed by a staff reading committee. The coverage, approach, and principal conclusions of this work were reviewed in last year's *Annual Report,* the major additions being further analysis of the impacts of inflation on the economics of both real estate projects and income participations.

A draft report of our related study of the use of equity kickers such as warrants and convertible features on lending in the private placement market also is being reviewed. Our field interviews with lenders, borrowers, and agents involved in a representative sample of financings to determine the factors on both the lenders' and borrowers' side that influenced the use or rejection of particular types of kickers are completed, along with our tabulations and statistical analyses of a large body of data from public sources as well as from our own extensive mail questionnaires. These mutually complementary sources of information and analysis show that the risk position of the borrower and his growth prospects were two of the most significant determinants of whether or not a particular debt financing would include an equity kicker. This was true during the years 1968–1969 when the use of kickers was most prevalent, as well as in other years when kickers were less frequently used in private placement financings.

Our manuscript on "Forward Commitments of Life Insurance Companies for Investments in Bonds and Mortgages" was submitted for staff review last summer and is being revised with a view to early publication. The scope and character of the analysis, and the principal conclusions of this work, were summarized in last year's *Annual Report.* During the year, we have also extended our analysis of the impact of in-

flation on the amount of funds available for investment through the various major financial institutions and its effects (in the context of other considerations) on their respective investment choices between fixed and variable dollar assets, particularly equity securities. We expect to have manuscripts on these further parts of our overall research program ready for review later this year.

Our investigations of the "Impact of Inflation on Common Stock Prices" have also been proceeding along several different fronts. Our previously reported findings that the net effect of inflation on equity returns is adverse have been confirmed and reinforced by several more detailed analyses of postwar data. Any such adverse effect on equity prices and returns from holding equities has usually been ascribed to such matters as weakened gross profit margins in the face of rising labor and material costs, the use of FIFO instead of LIFO accounting, and the valuation of fixed assets on historical rather than replacement costs by accountants and tax authorities. In our new theoretical work we have been able to show that—even if all these impairments of real returns in times of inflation were to be completely eliminated or neutralized by the use of replacement cost depreciation and LIFO accounting for inventories and even if real profit margins and rates of growth in unit sales could be maintained—increased inflation will nevertheless reduce stock prices and real rates of return on equity ownership. This strongly adverse effect on equities reflects the fact that, even under these favorable conditions, an increase in inflation necessarily increases each company's relative dependence on outside financing, and such outside financing either involves a direct dilution in the ownership interest of existing shareholders if new equity is issued, or an added dead-weight after-tax real interest charge against earnings on any new debt issued just to maintain real rates of growth. After a transition period during which heavy capital losses are consequently taken on equities, the expected future real rates of return (on holding equities at these lower prices) will recover to earlier levels even if inflation continues at a higher rate—and the model similarly shows that extraordinary (and potentially large) capital

gains will be realized on equities during a period when inflation rates are falling.

This new theory consequently explains the inverse relation between inflation and equity returns that has now been confirmed in the empirical data.[1] The other considerations, more traditionally emphasized in the literature but deliberately assumed away in this simplified model, are of course also important in practice and our studies of these matters are continuing. In particular, we have completed our simulation studies described in last year's Annual Report of the impact of "cost-push" considerations and price and wage inflation on the cyclical patterns of the (real and nominal) gross operating margins of private nonfinancial corporations. We have gone on to analyze with some care the cumulative real and nominal impact of interest charges on earnings and both the cash flow and income effects of historical rather than replacement cost depreciation and the use of FIFO instead of LIFO inventory accounting. This more general analysis has been supplemented by a review for each year since 1948 of the differences between the nominal-dollar reported profits and retained earnings of the U.S. private nonfinancial corporations and their corresponding real purchasing-power adjusted earnings and retentions.

We have been developing models of portfolio adjustments between holdings of stocks and bonds and short-term funds when the returns on each depend on expected inflation, and related models of shifting capital market equilibria with market-clearing equations for each interrelated sector. The insights from this theoretical work, along with the results of our other work on the effects of inflation on gross and net earnings, dividends, and interest rates, are being incorporated in a new quarterly model of stock market prices that explicitly incorporates interactions with other sectors, as well as the effects of inflation and inflationary expectations. All these interrelated studies of different aspects of the Impact of Inflation on Common Stock Prices will be brought together in a monograph

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1. A somewhat fuller summary of this new theory is given in Section II of Lintner's Presidential Address to the American Finance Association, published in the Journal of Finance, May 1975.

that should be ready for review later this year.

John Lintner
Thomas Piper
Peter Fortune

Convertible Bonds

A draft entitled "A Model of Convertible Bond Prices" has been submitted to a reading committee. The novelty of this paper lies in the effort to derive a measure of risk from actual security prices. The theory underlying this procedure implies a unique connection between the prices of convertibles in relation to their respective stock and straight bond values and the perceived riskiness of the stock.

The paper contains a theoretical model of convertible bond values and some preliminary empirical findings from the model. The salient feature of the model through which the measure of risk is obtained is its integration of the mathematical analysis of truncated distributions with the economic analysis of equilibrium asset pricing. The first concerns the projected value of the convertible on date of maturity, and the second provides the appropriate discount rate for determining the present worth of the convertible. The value of the convertible is affected by the variability of the underlying stock directly through the truncation effect and inversely through the discount effect.

According to the model only one measure of variability of the stock is consistent with an observed combination of the convertible bond price and related data. By expressing the theoretical value of the convertible as an implicit function of the variability of the stock and equating observed and theoretical values of the convertible, we inferred the one measure of variability of the stock that is consistent with the data. These estimates of variability differ from bond to bond and month to month. They decompose into values attributable to the particular time and to the particular bond. Averaging within a given month the estimates of risk of the sample bonds provides an estimate of the average level of risk for the given month. Similarly, averaging the monthly estimates of risk gives a measure of the riskiness of a given bond. Some average of the components of risk provides an a *priori* estimate of the riskiness of the stock at a given time. This estimate is available for use in a convertible bond model or for some other purpose.

The quality of this measure of risk is limited by the quality of the convertible bond model from which it is derived. In principle, it has several advantages over alternate measures and some disadvantages. Among the advantages of the proposed measure of risk is its grounding in actual market behavior; that is, in the relative prices of securities. Another is its variability over time. Among the disadvantages of the proposed risk measure is the failure to eliminate diversifiable risk.

The empirical measures obtained are quite stable. The means for the bonds and the months explain about 65 percent of the variation of the individual measures of risk for each bond in each month. In other words, differences in the measured riskiness of the bonds and the months are statistically significant. However, whether the measures give rise to plausible distinctions in the riskiness among bonds and among months still requires study. Even if they are found wanting in this regard, methods exist for improving the estimation of the model from which the risk measures are obtained.

Stanley Diller

Individual Investor Portfolio Performance

The growing role of institutional investors in the American equity capital markets has led to a number of investigations of the portfolio behavior and performance of such entities. However, there are virtually no hard data on the corresponding activities of the individual investor who manages his own portfolio. Our study seeks to fill that empirical vacuum by examining the investment history of a large sample of such individuals over a seven-year period ending with December 1970. The sample was obtained from the customer account records of a large national retail brokerage house, and the transaction information thereby acquired was supplemented by a questionnaire survey of the group.

The questionnaire yielded data on the investment objectives, decision processes, information sources, and asset holdings of the sample. Certain of those preliminary findings

were reported in a paper entitled "The Individual Investor: Attributes and Attitudes," which appeared in the May 1974, *Journal of Finance.* An examination of the cross-sectional profile of individual asset portfolio composition appears in the May 1975, *Journal of Finance* under the title, "Individual Investor Risk Aversion and Investment Portfolio Composition." The conclusion therein is a pattern of diminishing absolute and relative risk aversion with increasing investor wealth. The findings bear on the utility function assumptions of contemporary capital market theory. A paper entitled "Patterns of Investment Strategy and Behavior Among Individual Investors" has also been submitted for publication; it deals with the apparent linkages between investors' demographic circumstances and their investment policies, as well as with the interrelationships among the various elements of such policies. The findings suggest distinct differences in style that are manifest throughout the range of strategy components. Age, income, and sex are the dominant discriminating variables. That evidence is presently being extended to address the question of its implications for possible segmentation in the capital markets.

Data on the portfolio performance of the sample are now available. A manuscript, "Realized Rates of Return on Individuals' Investments in Common Stock," is in the final stages of completion. It consists of an examination, from the transactions record of the sample, of the returns realized on some 75,000 "round trips" in equity securities between 1964 and 1970—a round trip being defined as an event for which a complete purchase-to-sale cycle can be observed. Those returns are compared with the results of investing in a diversified portfolio of equivalent-risk equity securities for matching intervals. Evidence of some degree of differential skill in security selection by the sample emerges, that skill being most apparent for relatively short holding periods. Additional relationships between portfolio and transaction characteristics, and investment success or failure, are presently being explored.

This study has been assisted by grants from the Investment Company Institute and contributions of computer time by Purdue University.

Wilbur G. Lewellen

Information and Financial Institutions

I have been concerned with the conflict between many of our analytical models that are based on an assumption of near perfect knowledge and the regulation and operations of financial institutions built and operated on an assumption of either high costs for, or a lack of, information.

The institutional and regulatory structures that would be optimal if markets could approximate conditions of pure-perfect competition differ greatly from the actual markets around us. We would like to know whether the existing structure can be moved closer to the theoretical optimum and if so, what are the best ways in which the actual operations of our markets can be improved.

This problem of optimum structure is particularly acute among financial institutions. There is a strong feeling that unless major changes occur in the methods of regulation and competition among our financial institutions, our existing system is bound to experience major shocks with large potential losses. Much of recent academic literature describes dangers and inefficiencies in our existing structure. The Hunt Commission Report and the follow-on recommendations of the Treasury and the President agree that significant changes are necessary.

Many of these studies appear to assume away problems of information and dynamic instability. Events of the past year, however, have brought such questions back into prominence. Several major banks failed. Markets were swept with rumors of other possible failures. Investors seeking the type of information required to make logical decisions if the markets were to remain viable found it not available. Many firms decided to base their decisions on a model of regulatory authorities' behavior rather than on the market.

The regulatory authorities lacked needed information also. For the past fifteen years, there has been a debate over the proper level and function of capital for regulated financial institutions. One view has been that the market, left to itself, could and would determine capital adequacy. Such a result is not, however, obvious. Whether the market can perform this function depends on the cost and availability of information, on the type of risks involved, on the costs

of bearing such risks in the market as compared to the costs of government insurance, and on one's assumptions about the skills or lack thereof of the government regulators.

I hope to be able to build an improved model that will yield the type of information required to estimate portfolio risks of financial failure, the methods by which such information can be obtained, and the effect such a model may have on our general theories of capital adequacy and the regulation of financial institutions.

Sherman J. Maisel

The Relationship Between Interest Rates and Prices

The initial impetus for this research was the belief that cross-spectral analysis (along the lines suggested by Sargent) might shed light on the relationship between interest rates and prices. Several theories of interest rate behavior have consequences that can be distinguished in the frequency domain perhaps better than in the time domain.

The relationship in historical data between long-term interest rates and prices, often referred to as the Gibson Paradox, is a rather puzzling one. There is a high correlation between long-term interest rates and price levels, *not* the rate of inflation. The coherence between interest rates and prices operates primarily at the lower frequencies (wave lengths longer than ten years) for long rates, and at higher frequencies (wave lengths of three or four years) for short rates. I presented these results and discussed their connection with economic theory at the San Francisco meeting of the Econometric Society in a paper entitled "Expected Real Rates of Interest and the Gibson Paradox."

When I discovered that Jeremy J. Siegel of the University of Chicago was doing similar research, we decided to proceed together. We attempted to reconcile the cross-spectral results as much as possible with economic theory. A survey of the literature produced six "simple" explanations of the Gibson Paradox (which might also operate in concert to produce more complicated explanations): (1) prices affect inflationary expectations, which influence interest rates (Fisher); (2) interest rates affect the velocity of money, which affects prices (Sargent); (3) interest rates affect the money multiplier, which affects prices (Wicksell); (4) central bank efforts to stabilize interest rates affect prices (Keynes); (5) prices affect interest rates through the factor price frontier, since prices affect real wage rates because of money wage rigidity (Hawtrey, Sargent); and (6) price changes have distributional effects, which change interest rates (Macaulay, Siegel). Each of these theories was then evaluated in the light of the statistical properties of the series. The results are discussed in our joint paper, "The Gibson Paradox and the Historical Behavior of Real Long-Term Interest Rates."

I have also been working this year with Franco Modigliani to improve our modeling of the determination of long-term rates of interest. In an earlier paper (*Economica*, 1973) we proposed a model of the effects of inflation rates on interest rates. We are now working to improve the model by accommodating other extraneous influences such as tax effects and call effects.

Robert J. Shiller

Symposium on Regional Stock Exchanges in a Central Market System

On November 21–22, 1974, the National Bureau co-sponsored with the UCLA Graduate School of Management, the Norton Simon Foundation on the Business-Government Relationship, and the Pacific Stock Exchange a Symposium on Regional Stock Exchanges in a Central Market System.

The conference was organized around four substantive panels:

—legislative and regulatory developments affecting the structure of securities markets,

—impact of composite tape(s) on regional market centers,

—Impact of composite quotations on regional market centers, and

—regional impacts from the development of a national system for clearing and settling securities transactions.

The conference's focus was on the economic viability of regional market centers in the long

run, defined as commencing with the implementation of a central market system characterized by competitively determined brokerage commission rates, composite tape(s), composite quotations and improved clearance and depository systems, and the survival ability of regional market centers in the short run, defined as the period of transition from the introduction of competitively determined rates until composite quotations are obtained.

Principal speakers and panel participants included Congressman John E. Moss, Chairman of the Subcommittee on Commerce and Finance, U.S. House of Representatives; Commissioner Philip A. Loomis, Jr., of the U.S. Securities and Exchange Commission; and Deputy Assistant Attorney General Donald I. Baker of the Anti-Trust Division, U.S. Department of Justice. Also, G. Robert Ackerman, President, Pacific Stock Exchange; Donald L. Calvin, Vice President, New York Stock Exchange; Joseph P. Coriaci, Vice President and Cashier, Continental Illinois National Bank and Trust Company; James E. Dowd, President, Boston Stock Exchange; Donald E. Farrar, Professor of Finance in Residence, Graduate School of Management, UCLA; Donald M. Feuerstein, Partner and General Counsel, Salomon Brothers; David B. Heller, Vice President, Ralph W. Davis and Co.; Sidney Homer, Limited Partner, Salomon Brothers; Joseph F. Neil, Jr., Vice President, Merrill Lynch and Co.; Robert M. Newman, Jr., Partner, Weiss, Peck & Greer; William H. Painter, Professor of Law, University of Illinois; Harvey A. Rowen, Special Counsel, Subcommittee on Commerce and Finance, U.S. House of Representatives; David R. Rubin, Executive Vice President, Midwest Stock Exchange; Seymour Smidt, Professor of Finance, Graduate School of Management, Cornell University; Barry E. Tague, Executive Vice President and Vice Chairman of the Board, Raymond James and Associates, Inc., and Chairman of the Board, PBW Stock Exchange; Donald E. Weeden, Chairman of the Board, Weeden and Co.; Eli Weinberg, Senior Vice President, White, Weld and Co.; Elkins Wetherill, President, PBW Stock Exchange; and Harold M. Williams, Dean of the Graduate School of Management, UCLA.

Proceedings of the Symposium are scheduled for publication as Vol. 2, No. 3, the summer 1975 issue, of *Explorations in Economic Research*.

Donald E. Farrar

Industrial Institutions and Processes

Introduction

The National Bureau's research program in industrial organization continued in 1974 to focus on three categories of problems:

1. Studies of the determinants or consequences of technical change, examined at the microeconomic level.

2. Studies in the economics of information, marketing, and advertising.

3. Selected studies in industrial organization focused partly on studies of the growth of firms through diversification and partly on cross-sectional analysis of rates of return.

The first category includes the work of Grabowski and Mueller on returns to research and development outlays, capital equipment outlays, and advertising (a project that could also have been classified in categories 2 and 3), and my own work on the diffusion of product innovations. Both studies are approaching completion.

In the second category, three papers have been prepared. Michael Darby wrote a theoretical paper on the relation between the information available on product characteristics and market structure. Phillip Nelson submitted a manuscript on the role of search and experience as sources of consumer information and their effect on advertising. Henry Grabowski prepared a paper on the effects of advertising on interindustry shifts in demand. The latter two manuscripts have been reviewed by the staff and are currently being revised with a view to publication.

In the third category is a manuscript in preparation on mergers and diversification by Thomas Wilson and one on the determinants and consequences of diversification decisions by myself in collaboration with Henry Grabowski and Robert McGuckin. In addition, a paper on concentration and profit rates authored jointly by myself and Rao Singamsetti has been re-

viewed by the staff and will soon be submitted for approval for publication.

The National Bureau's research program in industrial organization has thus far been financed by grants for specific projects by the National Science Foundation and by a general support grant for studies in industrial organization and marketing by the Educational Foundation of the American Association of Advertising Agencies. In addition, the National Bureau has contributed to the program from general resources.

<div align="right">Michael Gort</div>

Returns to Firm Investment Outlays

We have completed a paper entitled "Rates of Return on Corporate Investment, Research and Development, and Advertising." In the paper we estimate long-run returns on three types of investment activities: capital equipment, research and development, and advertising. We also seek to determine whether R&D or advertising creates "entry barriers" that result in an increased return on total invested capital. We use multiple regression techniques to test if return on capital increases as a greater proportion of the firm's capital is "embodied" in R&D or advertising, using both linear and quadratic forms of the equation and checking for differences across industries.

In general, we find a positive relation between a firm's average return to its total invested capital and its research intensity. However, we also find the marginal return on investment in R&D in high research-intensive industries to be relatively low in relation to the average return on capital. Similarly, results hold with respect to advertising. This suggests that R&D and advertising may be successfully differentiating products vis-à-vis potential entrants (thereby increasing average returns for individual firms as well as the industry as a whole), and a high degree of competition with respect to these activities among existing firms causes marginal returns to decline to a competitive rate of return. Further evidence that this may be the case is provided by our results with regard to other factors, such as the concentration ratio, which is negatively related to profits but positively related to the degree of research intensity.

The paper, which was presented at the Econometric Society meetings in San Francisco, is currently being revised for publication.

Support for this work has come from the National Science Foundation.

<div align="right">Henry G. Grabowski
Dennis C. Mueller</div>

Diffusion of Product Innovations

This project has two components. The first, which is substantially completed, focuses on the characteristics of innovating firms. The specific question raised is whether product innovating firms become innovators by chance or whether there are consistent profiles that distinguish these firms from others in the corporate universe. Using factor analysis, it can be shown that innovators are distinguished from other firms by greater managerial aggressiveness as judged by expansionist policies, and policies generally associated with risk-taking, in the five years preceding the innovation. In this respect, the Schumpeterian hypothesis about innovators and imitators appears to be confirmed. A manuscript summarizing the results of this part of the study is in preparation.

The second, and principal, part of the project consists of an analysis of the determinants of the rate of diffusion of product innovations, and of the interactions among entry, the rate of innovations, prices, and demand. Several hypotheses are being examined. First, does entry, via its effect on the number of decision centers, influence the rate of innovation? Second, what is the relation, if any, between major and minor innovations and is this relation reciprocal? Third, what is the relation between the entry (or diffusion) rate and the rate of growth of the market? Fourth, do the initial attributes of an industry influence the rate of diffusion?

Data development for this project has now been completed. For approximately fifty product innovations we have compiled an annual history of entry into production and the number of patents issued. For a subset of roughly twenty products, reliable historical data have been developed on prices, output, and sales. In addi-

tion, a detailed history of all innovations subsequent to the initial introduction of the product has been compiled.

Analytically, a crucial problem involves the identification of phases of entry rates (diffusion), and of innovation as judged by rates of patenting. Conventional curve fitting, for a variety of reasons, was found inappropriate. Instead, two methods of analysis are being used. The first involves the identification of "switch points" for a given series followed by an analysis of the changes in other relevant variables associated with the switch points. The second involves the use of discriminant analysis in identifying phases in the relevant variables.

In order to identify changes in phases, a straight line is first fitted to segments of the data on entry or patents, with the segments selected by inspection of the plot of observations over time. A Chow test[1] is then used to determine if the slope of the line before and after the assumed change point differs significantly. This process is repeated for each potential change point and for each combination of change points. Once the phases are determined, the relation of the phases for the observed variable to changes in explanatory variables is then examined, with lag structures specified a *priori*.

An alternative approach involves the use of discriminant analysis. The objective is to identify phases by maximizing the difference between the mean vectors that characterize each phase, subject to a hypothesized multivariate distribution. Once the phases for each product are identified, regression techniques will then be used to "explain" cross-sectional variance (among products) in the length of the various successive phases.

Michael Gort

Qualitative Information and Market Structure

I have prepared a draft of a paper on the implications of qualitative information on the emergence of particular market structures.

Qualitative information refers to characteristics of a commodity that are known to buyer and seller after a transaction but that cannot be objectively demonstrated to a disinterested third party unless at prohibitive cost. In this paper I argue that market structures arise that minimize total average production and information costs relative to alternatives and that qualitative characteristics tend to produce structures utilizing either seller's or buyer's reputation. Were buyer and seller instead matched randomly, some form of moral hazard would result.

This analysis is directly applicable to Chamberlin's model of monopolistic competition. The analysis shows that Chamberlin's assumptions can be made consistent with utility maximization since a firm's reputation is fixed at an instant of time. However, the cost of acquiring a reputation implies that free entry and a price equal to average production cost are inconsistent. Full equilibrium occurs at the minimum point on the total average cost curve.

Other applications are to the labor market, the nature of the firm, and to situations involving many buyers and many sellers.

Michael R. Darby

Consumer Information and Advertising

I have completed a draft of a paper on the impact of consumer information on the behavior of product markets. My basic theoretical variables —the utility variance investigated by search and the utility variance investigated by experience— are not observable. But testable implications arise through the multiple implications of the theory. I have found that store clustering, retail mark-ups, and the percentage of print to total advertising expenditures are positively related to one another. Similarly, concentration ratios and national advertising expenditures are positively related. The two sets are negatively related to each other. These relations are predicted by the information model. All the correlations are statistically significant and generate substantial R^2's when each of the variables is treated as the dependent variable. From 30 percent to 60 percent of the variation in these variables is explained by the operation of the other variables. Although there are plausible alternative hypotheses for some of the relations, one is hard

1. Gregory C. Chow, "Test of Equality Between Sets of Coefficients in Two Linear Regressions," *Econometrica* 28, No. 3, July 1960.

pressed to find reasonable alternative explanations for most.

Phillip Nelson

Marketing and Advertising Studies

A paper entitled "The Effects of Advertising on the Inter-Industry Distribution of Demand" has been finished during the past year and submitted for publication. In this paper I undertake an empirical investigation of the effects of advertising on the level of consumer demand across broad product classes. Separate demand functions, which include relative prices and disposable income in addition to advertising as explanatory variables, are estimated for several consumption categories (e.g., food, clothing, drugs, automobiles, etc.). In addition to least squares estimation, simultaneous equation models are constructed and estimated that allow for a feedback relation between industry sales and advertising.

The most interesting results emerge from a comparison of the simultaneous equation and least squares results. Although initial least squares estimates indicated a statistically significant advertising effect on demand in several categories, the coefficients were insignificant except in a few high advertising-intensive categories after adjustments were made for both external advertising and simultaneous equation effects. On the other hand, in almost all consumption categories considered, sales was a strong explanatory variable of advertising outlays.

These findings, therefore, do not seem to provide much support for the hypothesis, advanced by Galbraith and others, that advertising has strong effects on consumer budget allocations even across product classes that are not close substitutes. Of course, these results do not imply that advertising has little or no effect on consumer decisions. As one deals with more disaggregate consumption categories, the effects of advertising on consumer demand might become stronger.

Henry G. Grabowski

Concentration and Profit Rates

A paper on the relation of concentration to profit rates, described in last year's Annual Report, has been reviewed by the staff and will soon be submitted for approval for publication. This paper was authored jointly by myself and Rao Singamsetti, and the research on which it is based was financed in part by the Educational Foundation of the American Association of Advertising Agencies.

Michael Gort

The Determinants and Consequences of Diversification

A manuscript that focuses on the determinants of the decisions of individual firms to diversify, and on the success or failure of such decisions as measured by profitability, will shortly be available for staff review. This study was carried out jointly by Henry Grabowski, Robert McGuckin, and myself.

Michael Gort

Mergers and Diversification

It now appears that, because of difficulties in access to the data, it will not be feasible to explore the relationship between indices of market concentricity, vertical integration and profitability within the context of multivariate models applied to data on individual businesses. Otherwise, the quantitative research on this project has been completed.

The first drafts of the following papers, which were outlined in last year's Annual Report, are about one-third completed: "The Measurement of Diversification;" "Diversification, Mergers, Size and Growth;" "Diversification and Profitability: An Analysis of the Determinants of the Rates of Return at the Business Level;" and "Diversification and Profitability: An Interindustry Analysis."

T. A. Wilson

5. INTERNATIONAL STUDIES

Introduction

The largest new project undertaken this year is a three-year study on Alternative Trade Strategies and Employment, directed by Anne O. Krueger, which will attempt to compare the impact of import substitution and export promotion on employment in developing countries. The Bhagwati-Krueger project on Foreign Trade Regimes and Economic Development is coming to its conclusion this year. Two regional conferences reviewing and evaluating the results of the project have been held, one in Manila, focusing on Asian countries, and one in Bogotá, focusing on Latin America.

The Bureau's participation in the U.S.-U.S.S.R. Scientific and Technical Program of Cooperation, announced in last year's *Annual Report*, was in full swing this year with a visit by a U.S. delegation to the U.S.S.R. and one by a Soviet delegation to the United States. The Bureau's main concerns this year are in cooperative programs on econometric models and the modeling of large-scale systems. John Meyer, Harvey J. McMains, and Edward K. Smith are directing the program.

The studies of multinational firms were concentrated mainly on the research on Multinational Firms, Technology, and Trade Flows, by Irving Kravis and Robert Lipsey, with the collaboration of several other investigators on several case studies. Their work on international prices will be extended in the coming year with the help of financing from the Office of Competitive Assessment of the U.S. Department of Commerce.

The cross-country study of the influence on monetary behavior of structural variables, such as income levels and the composition of output, has continued during the past year. It is described below by Henry Wallich, Francis X. Splane, and Mable Wallich.

Sherman Maisel reports below on a conference dealing with trade and economic development in the countries bordering on the Pacific Ocean, which is intended to explore the issues most needing research in this area.

Publications during the past year from the Bureau's international studies program on Foreign Trade Regimes and Economic Development include *Turkey*, by Anne Kreuger; *Ghana*, by J. Clark Leith; *Israel*, by Michael Michaely; and *The Philippines*, by Robert E. Baldwin. *India*, by Jagdish N. Bhagwati and T. N. Srinivasan; *South Korea*, by Charles R. Frank, Jr., Kwang Suk Kim, and Larry Westphal; and *Egypt*, by Bent Hansen and Karim Nashashibi, will appear before year's end. *Chile*, by Jere R. Behrman; *Colombia*, by Carlos F. Díaz-Alejandro; and *Brazil*, by Albert Fishlow will be published in 1976. Two synthesis volumes are being prepared by the Co-Directors. A paper on "The Structure of Ocean Transport Charges," by Robert Lipsey and Merle Yahr Weiss, was published in *Explorations in Economic Research*, Vol 1, No. 1, summer 1974. George Garvy's volume on "Money, Financial Flows, and Credit in the Soviet Union" is being prepared for submission to the Board of Directors.

Hal Lary, who was largely responsible for developing the Bureau's international studies program over the last fifteen years, has retired as Vice President-Research, but will still be called on as a consultant, with particular reference to the studies on developing countries.

Robert E. Lipsey

Alternative Trade Strategies and Employment

The objective of this project, funded by the U.S. Agency for International Development for a three-year period starting July 1, 1974, is to quantify the impact of alternative trade strategies on employment in developing countries. Broadly considered, the trade strategies to be studied are export promotion and import substitution. In the project proposal it was indicated that the first year would be devoted to the drafting of a paper on the underlying theory and the methodology to be employed and to working out arrangements with economists to carry out individual parts of the research. That initial work is now in progress, and a preliminary draft of the paper has been completed. The participants in the project will soon meet to discuss it and elaborate plans for their work.

The second stage of the project is to be devoted to the preparation of ten or more papers identifying and estimating the basic empirical relationships among export commodities, import-substitute commodities, employment, and trade strategies; those papers are to be undertaken by economists in the developing countries studied. In addition, several papers will explore various issues in depth for one or more countries, based partially on the findings of the individual studies.

The phase just described is expected to last until the end of 1976. A final phase will then entail writing up the research results in the form of an overall synthesis.

Anne O. Krueger

Foreign Trade Regimes and Economic Development

The broad purposes of this project, focused as it is on developing countries, are indicated by the titles of the two synthesis volumes being prepared by the Co-Directors; namely, the "Anatomy and Consequences of Exchange Control Regimes" by Jagdish Bhagwati and "Liberalization Attempts and Consequences" by Anne Krueger. With respect to the first of these topics suffice it here to say that, in most developing countries, the ability to increase foreign exchange earnings is regarded as crucial to economic growth, and that many or even most such countries have experienced difficulties in attaining the desired level and growth of foreign exchange earnings and have become enmeshed, for varying lengths of time, in trade and exchange regimes, including quantitative controls, of such complexity as to burden the administrative capacity and integrity of both government and business. With respect to the second topic, it can be said that experience with such regimes has typically led to attempts to shift to alternative systems through some combination of currency devaluation and reduction in direct controls, and that such attempts at liberalization have sometimes succeeded but have frequently failed, raising challenging questions about the economic and political conditions determining the outcome.

Thorough exploration of these questions has proved to be far more demanding in time and financial resources than was expected when the project was begun in 1970 under a research contract with the Agency for International Development. Each of the ten country studies carried out on the basis of a common analytical framework is becoming a full-scale volume in contrast to the briefer papers originally foreseen. Most of them are now in final or near-final state either already published or in press or as manuscripts nearing completion, as listed above.

Preparation of the syntheses by the Co-Directors has necessarily been geared to the longer production period for the country studies than originally foreseen, but they are now also nearing completion. Preliminary, partial drafts were reviewed at a meeting of project participants last September, and more advanced drafts figured on the agenda of two follow-up conferences, also financed by AID. The first, focusing on Asian countries, was held in Manila last December with the Asian Development Bank as co-sponsor and host. The second, focusing on Latin American countries, was held in Bogotá in April, with the Banco de la Republica as co-sponsor and host and the U.N. Economic Commission for Latin America also as co-sponsor.

Jagdish N. Bhagwati
Anne O. Krueger

U.S.-U.S.S.R. Scientific and Technical Program of Cooperation

In 1974, the NBER was again requested by the National Science Foundation to help plan and coordinate a program of cooperation in econometric models (Topic 1) and modeling of large-scale systems (Topic 2) under the U.S.-U.S.S.R. Scientific and Technical Program of Cooperation in the Field of Application of Computers to Management. There are five topics presently assigned in the area of Application of Computers to Management, and the Bureau has been given two. Don Aufenkamp of the National Science Foundation is Chairman of the U.S. side of the joint working group. Several meetings of the U.S.-U.S.S.R. coordinators and experts have been held, resulting in the formulation of a program agreed to by both sides in

protocols, which includes exchanges of information, conferences, seminars, and long-term visits. Initial work under this program has begun.

In July 1974 a U.S. delegation visited the Soviet Union. One group from the delegation participated in joint U.S.-U.S.S.R. seminars, in Moscow and Irkutsk, on management of the fuel-energy sectors with the use of computers and models. Another group from the U.S. delegation also visited research institutes of U.S.S.R. Gosplan and the Academy of Sciences and held discussions on modeling and measuring economic performance.

A Soviet delegation led by V. B. Bezroukov visited the U.S. during December 1974 and participated in scientific discussions at the Bell Telephone Laboratories; Exxon Research Laboratories and Exxon corporate headquarters; the Massachusetts Institute of Technology; NBER-Cambridge; Arthur D. Little, Inc.; Eastern Airlines; United Air Lines; the departments of Commerce (Bureau of Census), Health, Education and Welfare (National Institutes of Health), and Interior; and the Environmental Protection Agency and Federal Energy Administration. Topics examined included energy supply and demand models; productivity and costs of new computers; construction and operation of large-scale data banks; computer software for modeling and programming; airline computer systems for reservations, fleet scheduling, planning, and management control; pollution measurement, modeling, and control; decision-making in the utilization of natural resources; and operation of a large-scale, integrated time-sharing data network.

During the year 1974 over 100 experts from business, universities, and government have participated in the exchanges in the United States on topics 1 and 2. Exchanges of information under the program have resulted in the transmittal, by both sides, of several hundred books, journals, and scientific papers. Some of the Soviet materials received have been turned over to NBER and maintained at the Washington office. Annotated bibliographies of these publications, including brief translated abstracts of major works, are available, on loan, to individual scholars and organizations for research purposes.

Plans for 1975 include a seminar on transportation, a conference on mathematical modeling, seminars on the development of northern regions, at least one long-term exchange, and further meetings of coordinators and experts. These joint seminars, conferences, and planning sessions are to be held both in the U.S. and in the U.S.S.R.

U.S.S.R. Coordinator for Topic 1 is A. A. Modin, Deputy Director, Central Economics and Mathematics Institute of the Academy of Sciences of the U.S.S.R. Coordinator for Topic 2 is V. B. Bezroukov, Deputy Head of the Main Computer Center, GOSPLAN of the U.S.S.R. (For the U.S.S.R. both topics are under the direction of N. P. Lebedinskiy, Chief of the Main Computer Center of GOSPLAN and Deputy Chairman, State Planning Committee of the U.S.S.R.)

U.S. coordinators for the program are, for Topic 1, John R. Meyer, and for Topic 2, Harvey J. McMains. Other NBER senior personnel also serve on the staff coordinating committee in planning and directing specific portions of the program.

John R. Meyer
Harvey J. McMains
Edward K. Smith

Studies of Multinational Firms

The Bureau's studies of multinational firms are a set of related projects that draw to a large extent on a data base consisting of information on individual firms, unlike most past studies, which have been based on industry aggregates. The data base consists of two parts: the reports on individual U.S. firms and their foreign affiliates collected by the Bureau of Economic Analysis of the U.S. Department of Commerce and a variety of other data collected by the National Bureau. The Bureau does not have access to the Commerce Department files but computations on them and on combinations of the National Bureau and Commerce Department data can be performed at the Commerce Department. Several of the studies reported on below have used such computations.

The data base was begun as part of the study of the Relation of U.S. Manufacturing Abroad to U.S. Exports, financed mainly by grants from the

National Science Foundation and the Ford Foundation. It continued under a later grant from the Ford Foundation and under the study of the Impact of Multinational Firms on Technology and Trade Flows, reported on separately below.

The Office of Business Economics Surveys of sources and uses of funds and of trade of U.S.-owned affiliates abroad, 1962–1965, were the first element in the Commerce Department's part of the data base. We have recently been making extensive use of the 1970 Bureau of Economic Analysis survey of U.S. direct investment abroad. Certain data from the Office of Foreign Direct Investments are also part of our collection. The National Bureau data have, in addition, been linked to the comprehensive 1966 Commerce Department survey for later use.

The National Bureau's part of the data collection includes financial data for more than 2,000 corporations; their identification from public sources as foreign investors or noninvestors; a breakdown of about 1,300 firms' domestic employment in 1970 by four-digit industry; and similar, but rougher, breakdowns for several hundred firms for 1960 and 1965. Also part of the Bureau's data set is information from about 300 companies with more than 6,000 affiliates on the number, age, location, main industry, by SIC, and main product, by SITC, of each affiliate. These data were collected through questionnaires and public sources. Additional domestic data on individual companies are to be accumulated through the study on corporate microdata, discussed in Part II, Section 1, of this report.

The papers published so far on multinational firms are Robert E. Lipsey and Merle Yahr Weiss, "The Relation of U.S. Manufacturing Abroad to U.S. Exports: A Framework for Analysis," *1969 Business and Economic Statistics Section Proceedings, American Statistical Association*; "Estimating the Structure of International Transport Costs," *1971 Business and Economic Statistics Section Proceedings, American Statistical Association*; "Analyzing Direct Investment and Trade at the Company Level," *1972 Business and Economic Statistics Section Proceedings, American Statistical Association*; and "The Structure of Ocean Transport Charges," *Explorations in Economic Research*, Vol. 1, No. 1, summer 1974.

The new study of financial aspects of multinational firms by Rita Rodriguez, described in last year's *Annual Report,* has been delayed by data collection problems but should make better progress in the coming year.

Robert E. Lipsey

The Impact of Multinational Firms on Technology and Trade Flows

This project, financed by a grant from the National Science Foundation, involves three industry case studies of the relations among technology, investment, and trade; a broader survey of the same questions across all manufacturing industries; and the preparation of a bibliography on technology and trade.

The first of the case studies, by Benjamin Cohen, Jorge Katz, and William Beck, examines the U.S. pharmaceutical industry. The authors have assembled various measures of inputs into R&D and output of new products by twenty-two major companies, including a characterization of all their new drugs introduced between 1963 and 1972 as innovative or imitative. These measures of innovativeness are related to the individual firms' foreign investment and export behavior.

A second case study, by William Finan, is on the semiconductor industry. He prepared a list of major semiconductor innovations and their sources and discussed the roles of several types of semiconductor companies, their foreign investment behavior, and its determinants and effects on the flow of trade in components and finished products.

The third of the case studies, by Arthur Lake, examines the diffusion of innovations to and within the United Kingdom. He measures lags between first production in the United States and production in the United Kingdom, and the rates at which innovations spread among companies within the United Kingdom, and attempts to ascertain the effect of U.S. ownership of British firms on the initial lag and the rate of diffusion. It is expected that the work will cover the semiconductor industry, the pharmaceutical industry, and the synthetic materials industry.

The bibliography on technology and trade, which includes over 500 items, of which almost 200 are annotated, was prepared mainly by E. I. Paulinyi, after some preliminary work by others.

Two papers that originated from an earlier study of "The Relation of U.S. Manufacturing Abroad to U.S. Exports," by Robert Lipsey and Merle Yahr Weiss, are being completed under the present study. One is the working paper on "Multinational Firms and the Factor Intensity of Trade," which is being revised with the use of 1967 input-output data and improved estimates of the origin of U.S. imports. Another is a paper on pharmaceutical investment and trade that examines the impact of investment by United States and other pharmaceutical companies on imports by a cross-section of countries that are pharmaceutical importers and hosts to affiliates of United States and other pharmaceutical companies. We find that, on the whole, the presence of U.S.-owned affiliates in a country is associated with higher imports from the United States, particularly of bulk pharmaceuticals, and lower imports from thirteen other countries, and that the presence of foreign countries' affiliates is associated with higher imports from those countries but lower imports from the United States. The impression of the importance of rivalry among exporters is strengthened by the fact that U.S.-owned affiliates tend to be located where there are foreign-owned affiliates and that foreign-owned affiliates tend to locate where there are also U.S. affiliates.

Linda Quandt and Marianne Rey have performed the major data collection and programming within the National Bureau. We are also indebted to the Bureau of Economic Analysis of the U.S. Department of Commerce for the use of their data and to Arnold Gilbert of the BEA for programming calculations on the BEA data.

Robert E. Lipsey
Irving B. Kravis

The Role of Prices in International Trade

Our main efforts during the past year on this study, which was partly financed by the National Science Foundation, have been devoted to the preparation of price indexes for German domestic prices and German export prices on a common weighting scheme. These indexes are an extension of our earlier ones in several respects. They cover all manufactures, instead of only machinery and metals, they run through 1972, and they are available monthly from 1958. However, the coverage is not so complete as that of the annual indexes.

With the aid of some additional support from the Office of Competitive Assessment of the U.S. Department of Commerce we hope, in the coming year, to complete several studies. One is an examination of the determinants of the relation between export and domestic prices, using the German series, Japanese series to be developed as part of the study, and for those commodities covered by the Bureau of Labor Statistics export price indexes, U.S. data as well.

The second study will use our annual data in the metals and machinery groups to develop better estimates of price and substitution elasticities. We will disaggregate them into more homogeneous commodity classes at the three-digit or four-digit SITC level and, at the two-digit level, disaggregate by market, dividing the world into seven or eight regions.

Marianne Rey has been responsible for price collection and programming on this study.

Irving B. Kravis
Robert E. Lipsey

Trade, Finance, and Development Among Pacific Basin Countries

Much interest has been generated by questions of trade and economic developments in those countries bordering the Pacific Ocean. On December 6 and 7, 1974, a conference was held at NBER-West to discuss some of the critical research problems in this sphere. The papers and discussants included:

Speaker:
   Steven W. Kohlhagen, University of California, Berkeley
Title:
   "Direct Foreign Investment in the Pacific Basin"
Discussant:
   Raymond Mikesell, University of Oregon

Speaker:
   T. Y. Shen, University of California, Davis
Title:
   "Input Requirements, Technology Diffusion
      and Shifting Locational Patterns of
      Manufacturing Industries in the Pacific
      Basin"
Discussant:
   Paul A. David, Stanford University

Speakers:
   Bert G. Hickman and Lawrence J. Lau,
      Stanford University
Title:
   "Pacific Basin Econometric Models: A Survey
      and an Evaluation of Linkage Feasibility"
Discussant:
   Hang-Sheng Cheng, Federal Reserve Bank of
      San Francisco

Speakers:
   John Despres and C. Robert Roll, The RAND
      Corporation
Title:
   "Anticipating China's Economic Future"
Discussant:
   Feng-hwa Mah, University of Washington

Speaker:
   Kozo Yamamura, University of Washington
Title:
   "A Retrospect and Prospect of Postwar
      Japanese Economy"
Discussant:
   Leon Hollerman, Claremont Men's College

Other areas of possible research were ex-
amined during a general floor discussion.

Three of the papers containing reviews of
the relevant literature on these topics are in the
process of revision for publication. The papers
and their discussion indicated that our ability
to analyze policy problems and developments
in the Pacific sphere is hampered by a lack both
of theory concerning several of the issues and
of overall models that would enable analysts
to determine the probable interactions among
separate components of trade and development.
Many specific sector results presented in recent
studies of these topics depend for their results
on assumed relationships among exchange
rates. In turn, exchange rates depend on the re-
sults of trade, investment, and finance; but trade,
balance of payments, exchange rates, and
prices have not received the necessary integra-
tion.

We are exploring methods of improving the
analysis of the specific sectors by merging them
into a more general model that would include
their interactions.

Sherman J. Maisel

The Influence of Structural Variables on Monetary Behavior in Country Cross-Sections

This project calls for the use of international
cross-sectional data to investigate aspects of
monetary structure and behavior. One phase of
the examination has been directed toward the
demand for money. Per capita income, open-
ness, interest rates, and inflation have been
found to be significant in explaining variations
in the demand for money for aggregations of
national economies. Another phase of the re-
search has dealt with the relations between
monetary variables and economic growth. The
structure of the assets and liabilities of the
monetary system, the degree of openness, and
inflation were all found to be significant in ex-
plaining economic growth.

Presently being studied is the interrelation of
economic and monetary structure, focusing on
GNP components—exports, government pur-
chases, private investment, and personal con-
sumption—and the assets of the monetary
system—international reserves, claims on the
public sector, and claims on the private sector.
Still to be examined is the relation between
inflation and a variety of monetary variables.
Special attention will be accorded the variability
of factors such as inflation, exports, rate of
growth of money, and the rate of growth of GNP.

Differences in monetary behavior in various
countries are attributable to a considerable ex-
tent to differences in institutions, historical de-
velopment, and national preferences. Thus, the
explanatory value of the relationships examined
is rarely likely to be high. Nevertheless, it is
apparent from the results obtained so far that

certain regularities tend to hold across countries despite important intercountry differences. At the same time, the cross-sectional approach eliminates some of the difficulties associated with time series data.

In a separate application of the data, we will attempt to derive some insights into the welfare costs of inflation in terms of its degree of predictability.

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Henry C. Wallich
Francis X. Splane
Mable I. Wallich

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6. MEASUREMENT METHODS AND OPERATIONS

The Computer Research Center for Economics and Management Science

Introduction

The NBER Computer Research Center for Economics and Management Science entered its fifth year of operations in February 1975. The Center conducts research on algorithms for potential use in applied economic and management research; the new algorithms are programmed for an interactive, time-shared computer. The research community can utilize the Center's products by means of a national data-communication network maintained by the NBER's Computer Operations Activity.

The Center's research covers three broad areas: mathematical programming (MP), exploratory data analysis, and econometrics. The principal product in the MP area at this time is the SESAME system; SESAME is designed to solve large linear programming problems and is the first nonproprietary system of this type to be made available to the research community. Other MP research includes work on simplicial approximation (which has produced an experimental system called FIXPOINT) and on mixed integer programming.

Data analysis and econometric algorithms have to date been implemented as additions to TROLL. TROLL was originally designed for standard econometric modeling applications—i.e., single-equation estimation, simulation of simultaneous equation models, and supporting time-series manipulations. The Center's additions to TROLL have in the past year extended the scope of the system to such applications as robust and ridge regression, estimation of simultaneous equation systems, logit and probit analysis, spectral analysis, resistant and graphic analyses of data (along lines suggested by J. W. Tukey), and log-linear models.

Also during this past year, implementation of two software systems, ACOS and DASEL, has neared completion. ACOS will provide the system environment in which new algorithms, will be developed; DASEL is a specialized programming language in which algorithms will be written. The ACOS environment will for the first time permit attempts to use mathematical programming, econometric, and data-analytic algorithms in a fully coordinated manner—e.g., to achieve direct linkage of econometric and linear programming modeling.

The reports that follow discuss progress and plans of major projects at the Center. The concluding report, "Documentation and Training," lists by project the important software-user manuals that make recent work available for use by the research community.

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Edwin Kuh

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Data Analysis

The goal of the Center's Data-Analysis Project is to make interactive data analysis a real and significant alternative to current uses of the computer in data analysis. Over the last year, we have taken a number of forward strides toward this goal.

Robust and Ridge Regression

A major research interest has been robust regression—i.e., regression methods that are not sensitive to a few wild values or to small changes in the model or the data. The Center's programming staff has put together a TROLL subsystem that allows the user to apply various robust regression methods to his data. The user can perform least absolute residuals (LAR)

regression and the iteratively reweighted least squares improvements on it that have been suggested by Huber, Andrews, and Tukey. In addition he can obtain a plot, called a "Huber trace," that graphs the values of the regression coefficients as a function of a robustness parameter. This robust regression subsystem parallels a previously developed subsystem for ridge regression; the latter can offer a significant improvement in the estimation of coefficients if the data matrix suffers from near collinearity and if there are many parameters to estimate.

Roy Welsch has combined ridge and robust regression methods in a study of nonlinear models that arise in marketing, using nonlinear unconstrained optimization. The combination of ridge and robust regression leads to substantial improvements over simple least squares and related fitting methods in a variety of practical situations.

David Hoaglin has continued his research on asymptotic variances of location-parameter estimates and on related studies of random number generators. Hoaglin has begun to examine, both individually and jointly, such theoretical properties as lattice, spectrum, and serial correlation for a variety of generators.

Hoaglin, Welsch, and I are investigating inference procedures for use with robust regression methods that will allow the user to set confidence intervals, perform *t* tests, etc., much as he would using least squares, but without having to make unduly strong assumptions about the nature of the error distributions.

Much of this work was reviewed at a conference on Interactive Data Analysis and Econometrics held in Cambridge on October 4, 1974, under the auspices of the Center. Presentations were made by David Hoaglin, Ray Fair, Roy Welsch, G. S. Maddala, David Belsley, John Dennis, Jerry Hausman, Robert Engle, Forrest Nelson, and me.

A significant outgrowth of the work on robust and ridge regression is a plan to produce high-quality portable software that can be used by others for LAR regression, iteratively reweighted least squares regression, and ridge and robust-ridge regression for linear and nonlinear models. This project is being carried out jointly with the Center's numerical analyst, Virginia Klema, and

will continue over the next two years.

Log-Linear Models

Stanley Wasserman has written a TROLL subsystem that facilitates fitting Poisson regression models. It also incorporates a Bayesian extension to the usual Poisson model, which provides a ridge regression analogue. This subsystem supplements a group of TROLL functions, implemented last year, that allows the user to fit log-linear models to multidimensional contingency tables and to solve the inverse problem of adjusting a given data table to prescribed margins. Welsch and I have used these tools in a reanalysis of a large medical data set on heart disease in association with the Harvard Faculty Seminar on Human Experimentation in Health and Medicine. Nan Hughes helped in this effort and is now working on a thesis in the Department of Statistics at Harvard that will provide Bayesian extensions of the usual log-linear models. She is using the experimental TROLL programs in several novel ways in her work.

Paul Holland

Mathematical Programming

SESAME, the Center's interactive system for linear programming (LP), has been substantially tested and improved since its completion in 1974. It is now in use in several applications and has attracted the interest of many potential users. DATAMAT, a companion system for data management, including matrix generation and report writing, is completely coded and has been undergoing tests; it is now also ready for dissemination.

SESAME

SESAME is an interactive system for the solution and analysis of LP problems. It can solve general models with 2,000 or more rows and over 10,000 variables and can handle considerably larger problems having transportation or scheduling structures. SESAME has been designed, built, and maintained by William Orchard-Hays, Michael Harrison, and William Northup. Robert Fourer and Vinay Dharmadhikari have joined the staff to test the system, to produce documentation, and to assist users.

SESAME has undergone an organized test program, as well as considerable informal testing by staff members. The system's reliability has thereby been significantly increased. Experience has also suggested improvements and changes, including a capability for solving certain quadratic programming problems.

With testing fairly complete, our efforts have now turned to dissemination of SESAME through NBERNET, the Bureau's time-sharing network. The system's first applications have included simulations of the United States natural gas pipeline network (a project of the MIT Energy Laboratory), and solution of a model formulated at Brookhaven National Laboratory for energy-systems analysis and technology assessment (in cooperation with the Department of Transportation, Transportation Systems Center). With NBERNET's move to a larger and faster computer facility now complete, we expect that many others who have expressed interest in the system will begin work with it in the coming year. In addition, we expect work to begin at three foreign installations of SESAME established during the past summer—Vienna (International Institute for Applied Systems Analysis), Rome (National Research Council, Institute for Computer Applications), and Brussels (Center for Operations Research and Econometrics).

Users of SESAME are being aided by a new reference manual, which is being issued in installments to replace preliminary documentation. A set of maintenance procedures has also been established to ensure frequent and reliable updating at all installations.

DATAMAT

DATAMAT, an adjunct to SESAME, incorporates a flexible general language for generating LP models from basic data and logical relations. It also reads and analyzes LP results and produces formatted listings of selected result data. DATAMAT runs as a subsystem of SESAME. It will serve both as an aid to SESAME applications and as a tool for investigating techniques of data management and problem formulation.

DATAMAT was designed and coded by William Orchard-Hays, with some assistance from Michael Harrison. It is now undergoing final implementation testing and evaluation and is being made available to users of SESAME on a trial basis.

Robert Fourer

Mixed Integer Programming

During the past year, we have increased activity in the areas of mixed integer programming and discrete optimization. Bill Northup and I have begun work on a large-scale mixed integer programming system. This system uses the SESAME linear programming system as an important subroutine. In addition, it uses branch-and-bound tree-search methods, Benders' method for decomposing mixed integer programming problems into continuous and integer parts, number theory, and mathematical programming duality theory. We presented a paper on the design of this system and on computational experience with it at the Operations Research Society of America/Institute of Management Sciences meeting in Chicago in May 1975.

An innovative feature of the mixed integer programming system is the use of a new constructive duality theory for integer programming. Marshall Fisher and I described this theory in "Constructive Duality in Integer Programming," which appeared in the July 1974 issue of the *SIAM Journal on Applied Mathematics.* Fisher, Northup, and I have written another paper in which we extend the theory and supply computational experience; this paper will appear in a special studies volume of *Mathematical Programming.*

Integer programming dual problems can be viewed as large-scale linear programming approximations of a given integer-programming problem. Recent research has led to new methods for quickly approximating optimal solutions to these approximations using subgradient optimization. Bill Northup, Roy Marsten, and I have been experimenting with these methods on set-partitioning and covering problems and presented a paper about this work at the Operations Research Society of America/Institute of Management Sciences meeting in San Juan in October 1974. Roy Marsten has been doing additional computational research on hybrid dynamic programming and branch-and-bound approaches to nonlinear multiconstraint knapsack problems.

With the development of computational tools to perform mixed integer programming and discrete optimization, the Center has begun collaboration with researchers involved in applications. Larry Bodin and Don Rosenfeld of the State University of New York, Stony Brook, have sent us some large-scale personnel scheduling problems. We are working with Alan Manne of the Kennedy School, Harvard University, in testing a mixed integer programming model for public capital investment in India. Finally, we are exploring the possibilities of collaborating with the World Bank on the same general class of mixed integer programming investment problems. I presented a paper entitled "Multicriterion Public Investment Decision Making" at the Conference on Multicriteria Decision Making at Jout-en-Josas, France, in May 1975, in which I discussed how sensitivity analyses and multicriterion optimization can be carried out for mixed integer programming models.

Jeremy F. Shapiro

Simplicial Approximation

In the past year the Center has been developing a set of programs to compute approximations to fixed points of certain types of well-behaved mappings defined on a simplex. The programming has been done by Dennis Fromholzer of the Center in close consultation with Herbert Scarf of Yale University, a consultant to the Center and the originator of these simplicial approximation methods. John Geanakoplos, a student of Scarf, has also assisted in the programming.

These simplicial approximation methods have a wide variety of applications in the fields of economics, mathematical programming, and game theory. In economics they can be used in determining numerical solutions to the basic Walrasian general equilibrium model and many extensions of it, thus converting such models into more practical tools for evaluating economic policy. I have done some collaborative work with the Center in computing equilibria in economies with public goods. Jeremy Shapiro of the Center and Joseph Ferreira of the Urban Studies and Planning Department at MIT have begun using these methods in studying urban housing markets.

In the area of mathematical programming these methods can be used to solve a variety of unconstrained and constrained nonlinear optimization problems. Marshall Fisher of the University of Chicago has collaborated with the Center in applying these methods to the mixed nonlinear complementarity problem. Other applications include finding solutions to n-person games, such as Nash equilibrium points and points in the core.

The Center has completed an experimental system called FIXPOINT, which implements the main simplicial approximation algorithm. In addition, FIXPOINT provides a library of computer subroutines that can be used in conjunction with the main algorithm in solving standard problems such as the Walrasian general equilibrium model. However, in order to facilitate application of these methods to the wide variety of problems outlined above, FIXPOINT allows user-written subroutines to be combined with the main simplicial approximation algorithm.

The Center has finished the documentation of FIXPOINT and is distributing it to selected segments of the economics and management-science communities.

Donald Richter

Simultaneous Equation Systems

Recent progress by the Center's econometrics group centers around the continued development, implementation, and expansion of GREMLIN, a comprehensive system of simultaneous equations estimators accessible through the NBER's time-shared integrated network. Advances have been made in a number of coordinated directions:

1. Publication of the GREMLIN design specifications.
2. Implementation of GREMLIN.
3. Development of a nonlinear FIML facility.
4. Development of a nonlinear 3SLS facility.
5. Incorporation of diagnostics for multicollinearity.

Publication of GREMLIN Specifications

The design specifications for all parts of GREMLIN, except nonlinear three-stage least squares

(3SLS) and full information maximum likelihood (FIML), have been published in my article in the October 1974 issue of *Annals of Economic and Social Measurement*. This special issue on "Estimation of Simultaneous Equations Systems" also contains important articles by others who have coordinated their research efforts with the Center; these include Professors Dale W. Jorgenson (Harvard University), Jerry A. Hausman (MIT), and Ray C. Fair (Yale University).

Implementation of GREMLIN

The Center's programming staff has made major headway in implementing GREMLIN. The *k*-class modules, both linear and nonlinear, are now operational, and a programming environment called MOTHER was created to facilitate further programming of GREMLIN as well as other Center projects.

Nonlinear FIML

The published design specifications for GREMLIN do not contain a procedure for nonlinear full information maximum likelihood (FIML) estimation. The appropriate computational procedure for nonlinear FIML is still an open question. At best, nonlinear FIML is computationally cumbersome and hence invites research into efficient procedures. Kent Wall and I are now engaged in developmental experiments to determine an appropriate nonlinear FIML estimation procedure. John Dennis (Cornell University) is providing consulting support for the project and is developing a widely useful and efficient nonlinear optimization algorithm.

Nonlinear 3SLS

Another highly useful nonlinear full-information estimator is nonlinear three-stage least squares (3SLS). The 3SLS specification included in my published design specifications is specialized to linear 3SLS and takes advantage of factors that permit computational efficiency in that case. A nonlinear facility, however, is also needed and has become the subject of a project that is now beginning. Computational algorithms for nonlinear 3SLS are straightforward but again cumbersome, and efforts will be made to adapt any pertinent procedures that

may be developed for the nonlinear FIML project. Professor Takeshi Amemiya of Stanford University, a visitor at the Center for several months last spring, is also interested in nonlinear 3SLS estimation and directed some of his efforts to related estimation techniques.

Multicollinearity Diagnostics

Virginia Klema and I published an NBER working paper in December 1974 in which we suggested promising new diagnostics for the presence of collinear data and a means for assessing the damage that such collinearity may cause to estimated regression coefficients. This paper was delivered before the 1974 meetings of the Econometric Society in San Francisco and is now being circulated for critical review.

Efforts are under way to incorporate these diagnostic procedures into GREMLIN both as a passive watchdog to warn users of the possible presence of collinear data and as an interactive module for systematic investigation by the user of the quality of his data.

David A. Belsley

Time-Varying Parameters

The estimation theory necessary to handle problems with time-varying structure has progressed a long way in a relatively short period of time. It is now possible to formulate and estimate very general time-varying parameter structures with relatively little prior information. In addition, there are many areas of research in which the application of time-varying techniques appears very promising. Research by the Center's econometrics group has been focused on three areas: (1) theoretical problems, (2) simulation experiments and the development of efficient computational algorithms, and (3) applications to economic data.

Theoretical Issues

In the past several months, researchers at the Center have studied unresolved theoretical and conceptual issues that affect time-varying parameter estimation methods. One such issue is the identifiability of time-varying structures. Identifiability is fundamental in statistical inference, and identifiability conditions for constant

parameter models are well known. However, the identification of models whose structures vary stochastically over time requires more stringent conditions. Kent Wall and I[1] have established the conditions for the identifiability of time-varying structures, and have derived the asymptotic theory for a class of time-varying estimators.

Another issue with which we have been concerned is the development of time-varying parameter estimators for structures with non-Gaussian disturbances. If disturbances are non-Gaussian, then estimation can be improved by considering robust filtering techniques. Raman Mehra (Harvard) has been exploring the development of robust Kalman filters to deal with these problems.

Finally, attention has been directed to the development of varying-parameter estimators for simultaneous equation systems and the development of estimators that will be sensitive to the misspecification of models.

Simulation Experiments and Algorithmic Research

In order to make estimation methods for time-varying parameters more useful to researchers, additional experience with the practical problems of applying these methods is required. In the last *Annual Report* we described a large-scale simulation that was being carried out at the Center as a collaborative effort by researchers with a major interest in time-varying problems; this project is continuing. Several alternative estimation algorithms have been coded and installed in the TROLL system, and some simulation experiments have been performed. We expect to produce a monograph on the outcome of these experiments within the next year.

In addition to the Monte Carlo experiments, Center researchers have been concerned with improving the existing algorithms. A paper by Alexander Sarris[2] extends the standard Kalman filtering algorithm to problems that contain both stationary and nonstationary parameters.

Economic Applications

Varying-parameter estimators promise to improve the forecasting accuracy of econometric models and to provide more accurate estimates of econometric structure. Forecasting accuracy is likely to be improved because we can estimate more accurately the current state of the system before extrapolating to the future. Our knowledge of economic structure will be improved because we can trace the history of the parameters of the relationship.

In a recent paper[3] I explore the improvement in forecasting accuracy by comparing varying-parameter estimation and robust estimation of a small macroeconomic model developed by Ray Fair. The gain in forecasting accuracy obtained by using varying-parameter methods is considerable. Although the results are specific to this particular model, they encourage further research.

Stephen DeCanio and I[4] applied varying-parameter estimation methods to a problem in economic history in which knowledge of the changing structure of the economic relationships holds the key to understanding the origins of the Populist Movement of the 1890s. Many historians have argued that the Populist Movement had its origins in the inability of U.S. farmers to adapt to changing conditions in world agriculture. We estimated supply functions for wheat and cotton for all major agricultural states, using data from 1860 to 1915. We then traced the history of the parameters of these functions and tested to see if they conformed to models of rational behavior. Our conclusion was that the farmers adapted very efficiently to changing agricultural conditions, a conclusion that could not be supported solely on the basis of constant-parameter estimates.

These economic applications have improved our knowledge of the usefulness and difficulties of varying-parameter estimation and have pro-

1. T. F. Cooley and K. D. Wall, "On the Identification of Time-Varying Structures," NBER Working Paper No. 85, May 1975.

2. A. H. Sarris, "A General Algorithm for Simultaneous Estimation of Constant and Randomly-Varying Parameters in Linear Relations," NBER Working Paper No. 38.

3. T. F. Cooley, "A Comparison of Robust and Varying Parameter Estimates of a Macro-Econometric Model," NBER Working Paper No. 56.

4. T. F. Cooley and S. J. DeCanio, "Varying Parameter Supply Functions and the Sources of Economic Distress in American Agriculture 1866–1914," NBER Working Paper No. 57.

vided insights for the design of the user-oriented programs.

Thomas F. Cooley

Spectral Analysis and Spectral Regression

The focus of this project has been to provide user-oriented software for both spectral analysis and spectral regression, to carry out Monte Carlo tests of the performance of these procedures, and to apply them to empirical problems. The programs, tests, and several empirical studies of investment, consumption, and price dynamics are described in references 1–5, as well as in NBER manuals in the *TROLL Experimental Programs* series. These are summarized in last year's *Annual Report.*

This year, several software extensions have been derived and programmed in response to specific user needs. An empirical analysis of price dynamics has been completed and a study of Phillips Curves has been undertaken.

Program Extensions

In addition to improving existing spectral and cross-spectral facilities to afford users more flexibility, a new set of procedures for spectral regression is being programmed. These procedures, called generalized band spectrum regression, are designed to couple the problems of serial correlation and lagged dependent variables with the problem of excluding certain frequencies from a regression. Furthermore, it will now be possible to allow some coefficients to vary across frequency while others remain constant.

Empirical Studies

An analysis of the dynamics of price behavior has been completed and is described in reference 5; the work was done with Ken Wise. In the paper we examine disaggregate price equations in order to test whether the effect of rising factor costs on output prices is the same for cost changes that are viewed as permanent as for cost changes that are transitory. Using a spectral decomposition of the price and wage series, low frequencies are identified with permanent effects whereas high frequencies are transitory. The striking result is that permanent wage changes are more fully passed on to prices than are transitory changes.

A second empirical study has been initiated with Steve Sheffrin to investigate the other relation determining aggregate wage and price behavior, the Phillips Curve. Distributed lag relationships between the rate of change of wages and prices and unemployment are tested for differences across frequencies. Both established estimates of wage equations and new versions with new data have been tested. Initial results suggest that the low frequency effect of prices is greater than the high frequency effects, and therefore the Phillips Curve may be more vertical than was previously thought.

Theoretical Studies

Band spectrum regression has been proposed as a procedure for seasonal adjustment, particularly within the regression context. A theoretical and empirical comparison between this approach and a variety of alternative time series approaches has been initiated.

Robert F. Engle

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2. _____ and Duncan K. Foley, "An Asset Price Model of Aggregate Investment," forthcoming in *International Economic Review.*
3. _____ and Roy Gardner, "Some Finite Sample Properties of Spectral Estimators of a Linear Regression," forthcoming in *Econometrica.*
4. _____, "Interpreting Spectral Analysis in Terms of Time Domain Models," NBER Working Paper No. 37.
5. _____, "Testing Price Equations for Stability Across Frequencies," paper presented to Econometric Society Meetings, San Francisco, 1974.

Qualitative and Limited Dependent Variable Models

In June 1974 work began at the Computer Research Center on methods of estimation and

analysis for economic models with qualitative and limited dependent variables (logit, probit, and tobit analysis). This research has been carried out in close collaboration with Professor G. S. Maddala (University of Rochester), who served as a consultant to the Center during the summer of 1974.

This research emphasized methodological aspects, but attention has also been given to applications. A balanced approach is important because almost all interesting theoretical questions have arisen from problems encountered in empirical work. Consequently, applications are expected to determine the direction of future theoretical work and to provide tests for the adequacy of theoretical developments. A necessary interface between theory and application is a computer program package that incorporates the theoretical results in a form readily adaptable to empirical problems. Such packages are often necessary in analytic work as well—e.g., in sumulation experiments of estimator performance.

Our software-development effort has entered the second of two phases. The first phase was the preparation of prototype packages for logit models and for the general limited dependent variable model. This task was completed during the fall and winter of 1974 and served to test the adequacy of the user interface. The second phase involved upgrading to experimental level, and documenting, the two packages for release during the summer and fall of 1975.

Availability of this software on the TROLL system has promoted interaction with a number of continuing research projects that seek to apply qualitative and limited dependent variable methods. TROLL users at Harvard, Carnegie-Mellon, Rochester, and several National Bureau offices provided valuable feedback on the prototype software packages. In addition, involvement with these projects served to reinforce and in some cases redirect our methodological research.

With respect to that methodological work, several projects have been completed or are nearing completion. These include an investigation of the sensitivity of estimators to specification errors; aggregation in the context of qualitative variable models; some extensions of the

tobit and probit models—e.g., to models with censored dependent variables; and estimation of multivariate and simultaneous equation models with combinations of continuous, limited, and qualitative dependent variables.

<div align="right">Forrest D. Nelson</div>

Numerical Analysis

Substantial progress has been made this past year in developmental work in computational linear algebra and the optimization of an objective function.

In particular, work on determining the nearness of a data matrix to a rank-deficient matrix seems to be well in hand. Use of the singular value analysis is described in NBER Working Paper No. 46, and the interpretation of the singular vectors has been extended to determine the dependencies or near-dependencies among the variables (the columns of a matrix) or the equations (the rows of a matrix). The singular vectors of a rectangular matrix can be partitioned such that the range space and the null space spanned by the columns or the rows are exposed as a basis. A stable factorization of the basis corresponding to the null space reveals the relations that correspond to the dependencies or near-dependencies.

In finite arithmetic, singular vectors are not invariant to scale; however, their zero-nonzero structure can be made invariant to scale. Gene Golub (Stanford University) and Ake Bjorck suggested a matrix partitioning to show whether the selected rank of the matrix falls within the certainty of the data. The programming and documentation for the problem of near-dependencies are complete. The matrix factorization routines were programmed, tested, and documented by Neil Kaden.

Major work has been done on algorithms for the unconstrained minimization problem. Under the direction of John Dennis (Cornell University), we have implemented Powell's MINFA algorithm, the DOGLEG algorithm, the double DOG-LEG algorithm, Brent's PRAXIS, the Shanno-Phua descent algorithm, and Davidon's optimal conditioned algorithm. These algorithms represent the forefront of research in numerical analysis; they are, to some extent, less mature than

computational linear algebra and will perhaps need some modifications as testing proceeds. This testing and program documentation is being done by Mark Gelfand and Richard Wilk, with Dennis' advice.

We are developing the algorithms of numerical algebra as robust software. By robustness of software we mean that a program will resort to error recovery only if precise computational results cannot be achieved, and precise diagnostic messages will be provided. In short, the goal is to have the program detect and recover gracefully from unusual computing situations without terminating the computer run. The algorithms are thus strengthened and are semi-portable across machine lines.

Work on robust semiportable software has been extended to include some of the basic building blocks of robust statistics. These basic tools are used in iteratively reweighted least squares and ridge regression.

Further extensions in the development of high-quality software include modularization of algorithms for nonlinear unconstrained optimization. These algorithms are now mature enough so that their modules can be used as theoretical tools by both sophisticated users and numerical analysts.

Virginia Klema

Computer Programming

The Center's programming staff continues to provide support for ongoing research and has developed two systems that should revolutionize software development at the Center. New software-development methodologies, including structured programming and hierarchical design, have been successfully adopted and will ease maintenance problems.

System Software

The two large system-software projects of the programming staff are ACOS/ACOL, an operating system and control language, and DASEL, an algorithmic programming language. Both are complete in a prototype system and will be made widely available when we receive initial feedback on the prototype from internal users and close collaborators.

ACOS/ACOL, the Application Control System and Application Control Language, has been developed to provide a sophisticated environment for building and using interactive problem-solving systems. Walt Oney designed and implemented the file system and virtual machine supervisor. Annette Somers, Tom Dailey, and David Boyajian have been working on ACOL, though all the programmers have contributed to the design and implementation.

ACOS was designed to support many simultaneous users efficiently. David Anderson is implementing the programs required to meet this goal.

The DASEL language is designed to enable statisticians, econometricians, and other quantitative researchers to program their own algorithms quickly and easily. DASEL is a descendent of APL and TROLL. Joan Zahorjan has been the principal designer of the implementation, and each of the programmers has also made a contribution. David Rice has been working on the input/output interface and other application subsystems in ACOS for both character and graphical output.

Application Programming

The statistical application group (STAG), working closely with the various research projects in statistics and econometrics, has continued to develop experimental systems in TROLL, including three-stage least squares and limited dependent variables estimation. These experimental systems are now produced primarily by Mark Gelfand and Richard Wilk. MOTHER, a new facility to aid in the development of experimental systems, was written by Fred Ciaramaglia. Mark Gelfand has also been responsible for much TROLL maintenance and several enhancements. As ACOS/ACOL and DASEL become available, the application group will switch development work to the new system; an energy-modeling facility comparable in scope to TROLL should be one of the first application systems available under ACOS.

Support of Ongoing Research

The programming staff has made a substantial effort to improve TROLL maintenance and operating procedures in an effort to make TROLL as reliable as possible in light of the heavy use be-

ing made of it. Many of these procedures will be carried over and used in maintenance of the new software at the Center.

Gerald Ruderman
Richard Hill

Documentation and Training

Documentation is an integral part of the Center's system research and development process. The Center's support staff has general responsibility for writing instructional and reference manuals addressed to users of Center systems and for organizing and editing software design and maintenance manuals addressed to technical personnel.

In documenting new systems, the support staff tests them against design specifications and thus provides crucial inputs to the debugging process. In general, the documentation exercise facilitates management of system development, particularly with respect to quality assurance.

The support staff also edits and publishes working papers written by Center researchers. The support staff took general editorial responsibility for the September 1974 issue (Vol. 3, No. 4) of the NBER's quarterly journal, *Annals of Economic and Social Measurement*; this issue brings together a group of papers that emerged from a major Center research project on the estimation of simultaneous equation systems. Finally, the support staff consults with and assists researchers, both in-house and at collaborating institutions, who need help in using new Center systems.

Support staff personnel include Robert Fourer, Robert Perron, Gary Solomon, and Wayne Zafft (technical writers); and Sheila Howard (production assistant).

Following is a list of publications written or edited by the support staff during the fourth year of the Center's operations, February 1974–January 1975; the list is organized by project, each of which is described at length elsewhere in this report.

Mathematical Programming

FIXPOINT Reference Manual, D0092, 60 pp. Explains a system that implements H. Scarf's fixed-point approximation method and that permits adaptation and extension of that method.

SESAME: Design and Capabilities Overview, D0075, 40 pp. Describes, for prospective users, the design and capabilities of the SESAME linear programming system.

SESAME Primer, second edition, D0076, 100 pp. Explains basic system conventions and the use of a subset of capabilities for solving linear programming problems.

SESAME Reference Manual, second edition, D0077, 300 pp. Specifies all user-visible capabilities of the base system.

SESAME Reference Manual, Supplement 1: DATAMAT, D0087, 90 pp. Describes a data-management language that provides elaborate matrix-generation and report-writing capabilities for SESAME users.

Simultaneous Equation Systems

David A. Belsley, "Estimation of Systems of Simultaneous Equations, and Computational Specifications of GREMLIN," *Annals of Economic and Social Measurement*, Vol. 3, No. 4 (October 1974), pp. 551–614.

TROLL Experimental Programs: GREMLIN, Part 1, D0070M, 66 pp. Describes commands for using the k-class estimators, the first module of GREMLIN. (Future parts will cover three-stage least squares and full information maximum likelihood.)

Time-Varying Parameters

T. F. Cooley, "A Comparison of Robust and Varying Parameter Estimates of a Macro-Econometric Model," NBER Working Paper No. 56, September 1974.

T. F. Cooley, and S. J. DeCanio, "Varying-Parameter Supply Functions and the Sources of Economic Distress in American Agriculture, 1866–1914," NBER Working Paper No. 57, September 1974.

A. H. Sarris, "A General Algorithm for Simultaneous Estimation of Constant and Varying Parameters in Linear Relations," NBER Working Paper No. 38, April 1974.

Data Analysis

Robust and Ridge Regression

Richard W. Hill, and Paul W. Holland, "A

Monte Carlo Study of Two Robust Alternatives to Least Squares Regression Estimation," NBER Working Paper No. 58, September 1974.

TROLL Experimental Programs: Robust and Ridge Regression, D0070N, 123 pp. Explains the use of subsystems for regression analysis in the presence of contaminated data, outliers, and multicollinearity.

Log-Linear Models

TROLL Experimental Programs: Log-Linear Models, D0070M, 36 pp. Explains the use of a subsystem for fitting log-linear models to multi-dimensional contingency tables and for adjusting a given data table to prescribed margins.

Graphical Techniques

Roy E. Welsch, "Graphics for Data Analysis," NBER Working Paper No. 43, June 1974.

TROLL Experimental Programs: CLOUDS, D0070E, 147 pp. Explains the use of a subsystem for graphically displaying and analyzing multivariate data as "clouds" of points in an n-dimensional space.

TROLL Experimental Programs: FACES, D0070I, 49 pp. Explains the use of a subsystem for graphically displaying multivariate data as cartoon-like faces (implementing an idea of H. Chernoff).

TROLL Experimental Programs: STARS, D0070K, 49 pp. Explains the use of a subsystem for displaying multivariate data in circular graphs known as star plots.

Other

TROLL Experimental Programs: Miscellaneous Data-Analysis Tools, D0070C, 58 pp. Explains the use of a subsystem for statistical and graphical summaries of data, and for resistant analyses of data, along lines suggested by J. W. Tukey.

TROLL Experimental Programs: Probability Distributions, D0070D, 40 pp. Explains the use of a subsystem for computing (1) cumulative distribution functions of various probability distributions, and (2) pseudorandom samples from populations having various distributions.

TROLL Experimental Programs: Matrix Manipulation, D0070A, 108 pp. Explains the use of a subsystem for a wide range of computation, retrieval, and editing operations on two-dimensional matrices.

TROLL Experimental Programs: Matrix Labels, D0070B, 30 pp. Explains the use of utility subsystems for naming the columns and rows of matrices (for retrieval and printing operations).

Spectral Analysis and Regression

Robert F. Engle, "Interpreting Spectral Analyses in Terms of Time-Domain Models," NBER Working Paper No. 37, April 1974.

TROLL Experimental Programs: Spectral and Cross-Spectral Analysis, D0070F, 108 pp. Explains the use of a subsystem for estimating the spectrum of one time series and the cross-spectrum of two series.

TROLL Experimental Programs: Spectral Regression, D0070G, 67 pp. Explains the use of a subsystem for band-spectrum regression and for estimation in the presence of serial correlation.

Qualitative and Limited Dependent Variables

G. S. Maddala, and Forrest D. Nelson, "Analysis of Qualitative Variables," NBER Working Paper No. 70, October 1974.

Forrest D. Nelson, "On a General Computer Algorithm for the Analysis of Models with Limited Dependent Variables," NBER Working Paper No. 68, October 1974.

TROLL Experimental Programs: Qualitative and Limited Dependent Variables, D0070O, 60 pp. Explains the use of a subsystem for analysis and estimation of probit, tobit, logit, friction, and ordinal discrete models.

Numerical Analysis

R. Becker, N. Kaden, and V. Klema, "The Singular Analysis Decomposition in Matrix Computation," NBER Working Paper No. 46, July 1974.

TROLL Experimental Programs: Numerical Methods, D0070J, 23 pp. Explains the use of a subsystem for computing the singular value decomposition of a matrix and for other sophisticated algorithms of numerical algebra.

System Programming

ACOL Reference Manual, preliminary edition, D0085, 144 pp. Specifies the syntax and seman-

tics of the Applications Control Language, the user interface of the Center's new Application Control Operating System.

DASEL User's Guide, preliminary edition, D0084, 108 pp. Specifies the syntax and semantics of DASEL, a programming language for encoding statistical and mathematical algorithms.

John Kirsch

Distributed Lag Estimation

In an earlier paper (*Econometrica,* July 1973) I developed a Bayesian distributed lag estimator based on "normal smoothness priors" that should find use in a wide variety of applications. This year I explored important generalizations of this procedure and, in addition, developed a program that will make the estimator and its generalizations available to users of the TROLL system. Stanley Wasserman programmed the algorithm, which is named ε Shiller.

The most interesting result of this research is that a variant on the original distributed lag estimator is easily implemented and produces distributed lag estimates with very desirable properties. This variant is based on what we may call "log normal smoothness priors." Although the original distributed lag estimator was based on a spherically normal prior density on the vector of differences of order n of the distributed lag coefficients, the new estimator is based on a spherically normal prior density on the vector of differences of order n of the logs of the distributed lag coefficients. The posterior mode of the logs of the coefficients is easily derived with an iterative procedure. The resulting estimates are constrained to be positive and easily form asymptotes, but are otherwise free to assume any "smooth" shape. The limiting behavior of the new estimator (as the tightness parameter is increased to infinity) is identical to that of a maximum likelihood estimator subject to a truncated geometric (Koyck) constraint. In contrast, the limiting behavior of the distributed lag estimator based on normal smoothness prior is identical to the maximum likelihood estimator subject to the polynomial (Almon) constraint, which is usually considered less desirable.

The procedures are discussed with an illustrative example in my NBER working paper "Alternative Prior Representations of Smoothness for Distributed Lag Estimation."

Robert J. Shiller

Other Computer-Oriented Activities

The NBER Computer Service

The NBER Computer Service organization is responsible for the computer operations and software dissemination activities. Gerald Ruderman serves as senior technical adviser in this organization; John Kirsch as manager of user support; and Helen B. Munzer as operations manager. They are assisted by an able staff in the Bureau's New York, New Haven, and Cambridge offices.

The Computer Service (formerly the Computer Operations Activity) was established in 1973, and is responsible for coordinating the Bureau's computer and data-communications requirements; managing the Bureau's block purchase of computer time; and establishing standard rates for computer, communications, and terminal usage. These standard rates ensure the proper allocation of costs to all users.

During 1974 the Computer Service expanded the scope of its operations from coordination and financial control to operational matters. Major emphasis was placed on increasing the reliability and stability of the Bureau's computing and data-communication network facilities. (The network facilities enable researchers across the country to access TROLL and the new systems developed by the Computer Research Center.) Considerable effort was also made to provide a higher level of assistance and service to all users.

For the past three years the Bureau has purchased, under contract, a substantial block of IBM 360/67 computer time from Yale University. In order to facilitate future Computer Research Center software development and to take advantage of the latest computer technology, the Bureau switched its block purchase of computer time from Yale to Cornell University in March and April of 1975. The negotiation of a contract with Cornell and the planning for this changeover was a major effort of the Computer Service during the latter half of 1974.

Dissemination of TROLL made significant

progress during 1974. The system has been well received by the research community. Currently there are twenty-five to thirty academic, governmental, and other nonprofit institutions across the country who are using TROLL through the NBER's computer facilities. Access to the NBER computer facilities is made through a nationwide data-communications network. In addition, TROLL is being made available to time-sharing users in Canada through the facilities of IBM Canada and S.M.A., Inc. (Société de Mathématiques Appliques), TROLL is also running on a stand-alone basis at the University of Grenoble in France. During the year several other computing centers have requested and received copies of the TROLL systems source code.

A number of TROLL seminars, demonstrations, and workshops were held during the year. Owing to the increased usage of TROLL, formal TROLL education classes are being developed. The first class was given in the summer of 1975.

In 1975 a new CRC software system—SESAME—is being made available for limited, if not general, use by the research community. Plans are being formulated for the dissemination and support of this system.

Warren C. Lackstrom

NBER Data Bank

The National Bureau maintains an extensive collection of basic economic information for its research programs. Growing demand for these data from academic, government, and business users prompted the establishment in 1970 of the NBER Data Bank of machine-readable economic time series to make the data available at cost as a service to the economic research profession, governmental agencies, and business enterprises. Users of the Bureau's Data Bank increased rapidly during 1974 and is continuing to increase despite the fact that in January 1975 we had to raise subscription rates to meet higher costs.

Among the users there are now seven colleges and universities that receive daily updates and twelve who receive regularly monthly tapes. Other users include forty-three manufacturers and distributors, fifteen banks, two insurance companies, three utilities, five government agencies, and one hospital. Altogether we now have about eighty users of daily updates and about fifteen users of monthly or quarterly tapes.

During the last twelve-month period, there has been increased demand for the magnetic tape version of the data base. Before 1974 NBER magnetic tapes were distributed primarily to some universities and colleges for research and teaching purposes. Recently, many time-sharing companies have purchased tapes on a regular monthly or quarterly basis. These companies usually do not have enough users to justify daily updates. The time-sharing systems in this category are National CSS, Tymshare, Inc., Scientific Time Sharing, APL Services, and Time Sharing Resources.

Boeing Computing Services, which houses the Wharton Econometric Forecast model, has been added to the time-sharing systems that are updated daily. The others are Rapidata, GE's Information Management and Project System, and the Service Bureau Corporation's call 370 system.

The most important improvement this year is a new directory of the time series in the bank that will make it much easier to locate series and their code names, since it is arranged by subject matter and by source document. Another new feature is our cooperation with the Federal Reserve Bank of San Francisco. We are maintaining those series that are included in both data banks and they are making their entire collection available to us for internal use. Their data bank includes about 3,000 financial series and 795 industrial series. They have recently made a major effort, with some help from us, to improve the accuracy of their data.

In addition to the data maintained by the San Francisco Federal Reserve Bank we have access to the International Monetary Statistics published by the International Monetary Fund. The number of series we maintain in the bank is increasing slightly through the addition of the new indicators generated by the project on the evaluation of cyclical indicators (see the Zarnowitz and Boschan report on page 26).

Josephine Su
Charlotte Boschan

Machine-Readable Data Files

The machine-readable data files at NBER-NYC have been sorted, inventoried, and for the most part cataloged following the procedures proposed by John Byrum at the NBER-sponsored workshop on the Computer in Economic and Social Research held in mid-April 1974. The sorting process basically pulled together all tapes dealing with the same raw data so that they could be classified and ordered and an inventory could be kept. There are still some undocumented tapes and our efforts to locate owners, users, or documentation will be continued. A method of keeping a stock record or shelf list for each reel has been evolved, based on the Library of Congress classification system.

This method assigns each individual machine-readable data file its own unique number within a class number, similar to the open-ended treatment of library material published in series.

We have prepared a directory of the data tapes owned by the Bureau based on subject content. The directory format is still experimental and is for internal use only. A brief description of the machine-readable data file is given under a main subject heading with cross references from title, author, or other subject headings, and catch titles. This description contains little or no technical detail, being a listing of variables, kinds of content, time span if pertinent, users, and persons to contact for either documentation or technical information.

Ann Wood

7. CONFERENCES, WORKSHOPS, AND OTHER PROGRAMS

Conference on Research in Income and Wealth

The Personal Distribution of Income and Wealth, the proceedings of the October 1972 sessions of the Conference, has recently been published as volume 39 of *Studies in Income and Wealth.* Publication of volume 40, the proceedings of the December 1973 Conference on Household Production and Consumption, is anticipated late this winter or early in 1976. The papers from the May 1974 Conference on the Distribution of Economic Well-being is in press, and the papers from the November 1974 Conference on Price Behavior are being readied for submission.

A conference on the Economics of Residential Location and Urban Housing Markets, under the chairmanship of Gregory K. Ingram, was held on May 15–16, 1975 at the Fenway Cambridge Motel. The following papers were presented:

An Analysis of Ghetto Housing Prices over Time
Ann Schnare and Raymond J. Struyk, The Urban Institute
Census Data and Housing Analysis: Old Data Sources and New Applications
William C. Apgar, Jr., National Bureau of Economic Research

Habitability Laws and Low Cost Rental Housing
Werner Z. Hirsch and Stephen Margolis, University of California, Los Angeles
Interdependencies between Public Sector Decisions and the Urban Housing Market
Mahlon R. Straszheim, University of Maryland
The Influence of Age of Dwellings on the Location of Households by Income and on Housing Expenditures
Richard F. Muth, Stanford University
The Urban Institute Housing Model
Frank de Leeuw, Congressional Budget Office, and Raymond J. Struyk, The Urban Institute
The Behavior of Housing Producers
Gregory K. Ingram, Harvard University, and Yitzhak Oron, National Bureau of Economic Research
New Developments in Productivity Measurement is the subject of a conference to be held in November 1975 in Williamsburg; this conference is to be financed jointly by the National Science Foundation and the National Commission on Productivity and Work Quality. Beatrice N. Vaccara and John W. Kendrick are serving

as co-chairmen. The following papers are planned:

Quarterly Estimates of Total Factor Productivity, by Industry Groups
John W. Kendrick, George Washington University

Total Factor Productivity by Industry, 1947–1974
Dale W. Jorgenson, Harvard University, and Frank Gallop, University of Wisconsin

Inflation and Productivity Accounting
Solomon Fabricant, National Bureau of Economic Research

Labor Productivity and the Business Cycle
Michael F. Mohr and J. R. Norsworthy, Bureau of Labor Statistics

Estimating Direct and Indirect Effects of R & D on Productivity Growth by Industries
Nestor E. Terleckyj, National Planning Association

R&D and Productivity at the Firm Level
M. I. Nadiri and George C. Bitros, New York University and National Bureau of Economic Research

An International Comparison of Productivity Growth, 1950–1973
Diane and Laurits Christensen, University of Wisconsin, and Dale W. Jorgenson, Harvard University

International Comparisons of Productivity in Agriculture
Vernon Ruttan, The Agricultural Development Council, Inc., and Saburo Yamada, University of Tokyo

Interquartile Differences in Labor Productivity
Benjamin Klotz, The Urban Institute

Measurement and Analysis of Productivity in Transportation Industries
John R. Meyer, Harvard University and National Bureau of Economic Research

Current Efforts to Measure Productivity in the Public Sector: How Adequate for National Accounts?
Charles A. Waite, Bureau of Economic Analysis, and Allan D. Searle, Consultant to the Bureau of Economic Analysis

Dan Usher is planning a conference on the Measurement of Capital for the fall of 1976, and Frank de Leeuw is exploring the possibility of holding sessions on effects of inflation.

The conference program is assisted by a grant from the National Science Foundation. Members of the Executive Committee are: Dorothy S. Projector (chairwoman), Clopper Almon, Robert M. Coen, Martin L. Marimont, Geoffrey H. Moore, J. A. Sawyer, James D. Smith, Eugene Smolensky, Dan Usher, Burton A. Weisbrod, and Mildred E. Courtney (secretary).

Mildred E. Courtney

Universities–National Bureau Committee for Economic Research

A conference on the Economic Analysis of Political Behavior was held on April 11–12, 1975, in Cambridge, Massachusetts. Melvin W. Reder was chairman of the Planning Committee, which also included Thomas C. Schelling and George J. Stigler.

The conference volume *Economic Analysis of Environmental Problems*, edited by Edwin S. Mills, was published this summer. The volume of proceedings of the conference on the Role of Health Insurance in the Health Services Sector, edited by Richard N. Rosett, will be published in early 1976 and that on Education as an Industry, Dean Jamison, Joseph Froomkin, and Roy Radner, co-editors, in late 1976.

The two next conferences being planned by the Committee are Causes and Economic Effects of Population Changes in Less Developed Countries, Richard Easterlin, Chairman of the Planning Committee, to be held in September 1976; and Low Income Labor Markets, Sherwin Rosen, Chairman of the Planning Committee, to be held in late 1976 or early 1977. There is also an Exploratory Committee on Taxation and Household Behavior with Martin Feldstein as Chairman.

The Universities–National Bureau Committee for Economic Research at its annual meeting held in conjunction with the conference on the Economic Analysis of Political Behavior selected two topics to be considered for future conferences: Economics of Information, and Planning and Regulation.

There are now forty universities, with the National Bureau, represented on the Committee. The participating universities are:

Brown
Buffalo
California, Berkeley
California, Los Angeles
Carnegie-Mellon
Chicago
Columbia
Cornell
Duke
Harvard
Illinois
Indiana
Iowa State
Johns Hopkins
Maryland
Massachusetts Institute
  of Technology
McGill
Michigan
Michigan State
Minnesota
New School for
  Social Research
New York
North Carolina
Northwestern
Ohio State
Pennsylvania
Pittsburgh
Princeton
Purdue
Queen's
Rochester
Stanford
Texas
Toronto
Vanderbilt
Virginia
Washington (St. Louis)
Washington (Seattle)
Wisconsin
Yale

Other members of the Committee, elected as members-at-large for a four-year term, July 1, 1974–June 30, 1978, are Irma Adelman, Daniel Creamer, Walter S. Salant, and George J. Stigler. Robert E. Lipsey is the representative from the National Bureau of Economic Research.

The members of the Executive Committee are Edwin S. Mills (chairman), Leonard W. Weiss (vice chairman), Irma Adelman, Richard Bird, Robert Eisner, Robert E. Lipsey, and Dudley G. Luckett. Christine Mortensen is secretary.

The conference program is assisted by a grant from the National Science Foundation.

Universities interested in membership on the Universities–National Bureau Committee for Economic Research should get in touch with the Chairman of the Committee. The criterion for acceptance of a university as a member of the Committee is the extent and quality of economic research carried on at that university.

Universities wishing to be informed about proposals for future Universities–National Bureau Committee research conferences, and about the availability of conference papers before publication, should communicate with the Secretary of the Committee.

Christine Mortensen

Conference on Econometrics and Mathematical Economics (CEME)

This conference, now in its fifth year, continues to stimulate research at the frontiers of the state-of-the-art on topics in mathematical economics and econometrics. The program, created and sponsored from its inception by the National Science Foundation, operates through a series of seminars which meet periodically at universities and research centers.

The seminars and their leaders are:

General Equilibrium Models—Kenneth J. Arrow, Harvard University and Gerard Debreu, University of California, Berkeley

Evaluation of Econometric Models—Saul Hymans and Harold T. Shapiro, University of Michigan

Comparison of Econometric Models—Lawrence R. Klein, University of Pennsylvania

Decision Rules and Uncertainty—Daniel L. McFadden, University of California, Berkeley

Decentralized Economic Planning and Programming—Roy Radner, University of California, Berkeley

Bayesian Inference in Econometrics—Arnold Zeller, University of Chicago

Natural Resources and Economic Growth—Joseph E. Stiglitz, Stanford University

Quantitative Studies in Industrial Organization—George J. Stigler and Lester G. Telser, University of Chicago

Monetary and Fiscal Analysis—William C. Brainard, Yale University and Franco Modigliani, Massachusetts Institute of Technology

Analysis of Panel Microdata—James N. Morgan, University of Michigan

Public Economics and Nonmarket Decisions—Martin McGuire and Mancur Olson, University of Maryland

Distributed Lags and Time Series Analysis—Christopher Sims, University of Minnesota

Meetings of the seminars have resulted in numerous publications, including two monographs during 1974 from the Bayesian Inference and the Decision Rule and Uncertainty groups. The *International Economic Review* published a symposium in three issues (1974: 2, 3 and

1975: 1) on work of the Comparison of Econometric Models seminar and this same group has been invited to organize and present a session at the annual meetings of the American Economic Association to be held in Dallas, Texas in December 1975.

Two seminars are holding NSF-sponsored workshops in early 1975 in conjunction with their regular meetings. The Monetary and Fiscal Analysis group's session is on Commodity Prices, Energy, and Inflation and that of the Natural Resources and Economic Growth seminar is on Energy Related General Research in Microeconomics. The workshops are organized to examine existing knowledge on their respective topics and then to explore possibly fruitful avenues of research. Rapporteur's reports on the seminar/workshops will be widely disseminated.

This year, also, it is hoped that joint meetings will begin with participation of Soviet economists under the U.S.-U.S.S.R. Scientific and Technical Program of Cooperation.

Gary Fromm

Workshops on the Computer in Economic and Social Research

Five workshops were held during 1974 under the auspices of the Conference on the Computer in Economic and Social Research (CESR). The first workshop, on Large-scale Urban Simulation Models, organized by Professor James Brown of Harvard University, was held on February 8–9, 1974, in Cambridge, Massachusetts. Twenty-five economists attended the workshop, and the major topics considered were: the NBER Urban Simulation Model, the Urban Institute Model, Future Directions of Urban Simulation Models, and the Equilibrium Analysis of the Urban Institute Housing Model. A workshop on Documentation of Large Machine-Readable Statistical Data Sets, organized by Charlotte Boschan, was held at New York University on April 18–20, 1974. Some of the topics discussed were Standards for Description of Storage Media, Documentation for Interactive Use of Time Series Data Bases, and Potentials and Problems of Data Base Documentation in Machine-Readable Form. The third workshop for

the year, on Household Theory for Consumer Expenditure Data, was held at NBER-West, Palo Alto, California, on May 2–3. It was organized by Lester Taylor of the University of Michigan. Topics for discussion included Exercises in the New Theory of Demand and Consumer Budgeting, Estimation of Complete Systems of Demand Functions, and Theory of Cost of Living Indexes.

The fourth workshop, on Stochastic Control Theory, was held on May 29–31, 1974, in Washington, D.C. The conference was organized by Michael Athans, Gregory Chow, and James L. Pierce, and it was jointly sponsored by the National Bureau and the Board of Governors of the Federal Reserve System. The topics discussed were Discretion in the Choice of Macroeconomic Policies, On Selecting Economic Targets, Optimal Coordination of Aggregate Stabilization Policy and Price Control, Optimal Monetary Policy, Control Solutions to the Mini SSRC-MIT-Penn Model, A Solution to Optimal Control of Linear Systems with Unknown Parameters, Decentralized Stochastic Control Methods, An Optimal Control Problem with a Linear Feedback Solution, and Optimal Stochastic Control of Environmental Externalities. Over 100 economists and engineers attended the two-day workshop.

A fifth workshop, on Computer Techniques on Data Analysis, was organized by Paul Holland and was held at the NBER Computer Research Center in Cambridge on October 4–5, 1974. About fifty economists and statisticians attended the meeting. The main topics discussed were: The Robust Regression Estimation Techniques, The Ridge Regression, Various New Methods to Solve Multicollinearity, and New Methods of Estimating Simultaneous Equations.

M. Ishaq Nadiri

Latin American Computer Workshops

The fifth workshop in this series, held November 27–29, 1974, in Mexico City, dealt with The Use of Econometric Models in Latin America. The workshop, co-sponsored by the Center of Economic and Demographic Studies of El Colegio de Mexico and the National Bureau of Economic Research, was organized by Manuel Gollás of El Colegio de Mexico and M. Ishaq

Nadiri of the National Bureau. About sixty economists from Latin American countries and the United States participated in the workshop. Samples of topics discussed were: A Linear Programming Model of Mexican Agriculture, The Estimation of Production Function and Efficiency Frontiers for Industrial Plants of Different Sizes in Chile, An Econometric Approach in the Estimation of Basic Aggregates, A Short-run Macroeconomic Model of the Chilean Economy, A Model of Price Stabilization Policies for the Brazilian Economy, A Model of Fiscal Policy for the Mexican Economy, and A National-Regional Macroeconometric Model for Argentina. An edited version of some of the papers discussed at the workshop will appear in the *Annals of Economic and Social Measurement*. The discussion at the workshop focused mainly on the use of these econometric findings for short- and long-run planning in Latin American economies.

A major conference on Monetary Correction or Indexation, the sixth in the series, was held February 26–28, 1975, in São Paulo, Brazil. The conference, co-sponsored by the Instituto de Pesquisas Economicas (IPE) of the University of São Paulo, was organized by Affonso Celso Pastore of IPE and M. Ishaq Nadiri of the National Bureau. Over 100 participants from various countries (Germany, Israel, England, Switzerland, Mexico, Argentina, Brazil, and other Latin American countries) were present. The main purpose of the conference was twofold: (1) to examine the Brazilian experience in indexation, and (2) to discuss the "exportability" of the Brazilian experience to other countries, both developed and industrialized. Some of the topics discussed were: The Evaluation of Brazil's Indexing System; Indexation in the Labor Market; Monetary Correction of the Exchange Rates and Bank Deposits in Brazil; and Indexation Experiences in Canada, Israel, Argentina, Chile, Colombia, and Germany. The administrative implementation of these Brazilian experiences was analyzed in some detail. The relevance of the Brazilian experience for highly industrialized economies in their efforts to combat inflation and to limit the adverse redistributive effect of high rates of inflation was discussed in great detail. A select number of

papers given at the workshop will be submitted to *Explorations in Economic Research,* and a book containing the proceedings of the conference will be published subsequently.

This series of workshops has been made possible by a grant from the IBM World Trade Corporation and the Ford Foundation.

M. Ishaq Nadiri

Policy Application of Models

Models increasingly are being utilized by the private sector and by governments in developing understanding of physical, economic, social, and other phenomena and for forecasting and simulation of the impacts of different structural and policy scenarios. The art of model building has advanced over the past decade to the point where few processes that can be expressed in analytical terms or forms are not being depicted by sets of mathematical equations. As shown by the Survey of Federal Modeling Projects, the scope of application of models today is extremely wide, ranging from simulation of agricultural production processes, to predicting economic events, aspects of the legal and prison system, population and urban dynamics, and weather forecasting and, modification.

Although many models are being used in these and other areas for policy prescriptions, few of them have undergone more than cursory tests to ascertain their validity and reliability. In part this reflects deficiencies of model builders and users. But, also, it is attributable to lack of adequate criteria and methods for determining whether a model accurately depicts a structural process or phenomenon.

A related subject that has received little attention is the requirements and institutional framework necessary for the effective use of models in policy applications. Preliminary results from the Federal Modeling Survey indicate that most present-day models are not utilized directly in the consideration and selection of policy alternatives but rather form part of the background underlying policy choices. Solutions and simulation from models appear to help educate model builders and policymakers about the characteristics of the subject under study and the range of possible outcomes from

different choices. But rarely are the outputs from models an important direct input into specific policy decisions. Perhaps this is explicable given existing limitations of the state of the art of specification of models, their predictive accuracy, and the paucity of validation techniques. Yet it may in large measure also be attributed to an inadequate institutional framework and appropriate procedures and information flow between model builders and policymakers.

The need to explore model validation and public policy use issues and to improve validation procedures and techniques, the extent of their application, and the potential utilization of models for public policy decisions has been recognized by the National Science Foundation in its support for planning a joint NBER-Social Science Research Council conference on the subject. Planning meetings and discussions with leading statisticians, economists, sociologists, operations researchers, and political scientists have led to a tentative agenda for the conference. This agenda and the topic in general was the subject of a workshop held in St. Louis and Denver June 12–13, 1975. Plans are to hold the conference in Washington, D.C. in 1976.

Gary Fromm

Flow-of-Funds Model

Understanding the structure and functioning of the U.S. economy increasingly entails knowledge of interactions between the financial and "real" sectors. Funds availability and costs act as constraints on consumption and investment expenditures and influence the magnitude and timing of goods and services purchases. Simultaneously, the volume of real activity creates income and demands for funds that impinge on financial markets. Although these interactions have long been recognized, it is only within recent years that this process has been subjected to intensive scrutiny and efforts have been made to construct flow-of-funds models incorporating extensive detail of financial accounts, interindustry flows, and the foreign sector. The pursuit of this objective at the NBER, conducted with the support of the National Science Foundation, is being undertaken in cooperation with complementary efforts on flow-of-

funds modeling at Yale, Pennsylvania, Princeton, and Harvard. Data Resources, Inc., also has participated and contributed to the research.

An initial submodel of the mortgage-housing sector, including flow-of-funds equations for households, has been estimated and was presented by Gary Fromm and Alan Sinai at the December 1974 Econometric Society meetings. This work builds on earlier analyses by positing a deposits-mortgages-housing set of linkages wherein desired holdings of selected financial and physical assets by sector depend on "own" and alternative rates of return for each investment and on budget constraints. Essentially, the submodel takes a portfolio adjustment form. Partial adjustment mechanisms provide a convenient method for permitting consistent and systematic convergence of actual to desired states. The sectors included in the model are households, commercial banks, savings and loan associations, mutual savings banks, and life insurance companies. The instruments are deposits (by type), commercial loans and paper, Treasury bills, bonds, and mortgage commitments, acquisitions, and holdings.

The deposit, mortgage flow, and housing sector equations were estimated by OLS and TSLS techniques and were combined with the 1973–1974 DRI model. The effects on housing of numerous policies, including changes in nonborrowed reserves, reserve requirements, Federal Home Loan Bank advances, the discount rate on such advances, FNMA and GNMA purchases of mortgages, Federal Home Loan Mortgage Corporation commitments to purchase mortgages, required liquidity ratios at savings and loan associations, and deposit rate ceilings were obtained by model simulations. In general the preliminary results reveal that Federal Reserve monetary actions are more powerful than actions of specialized mortgage sector agencies in their impact on housing activity.

Gary Fromm

Public Forum on Economic Issues

Concern about the public's isolation from consideration of economic policies that so vitally affect it has stimulated a number of leading economists to seek a forum to meet the need

for greater public understanding of the nation's current economic problems. A careful examination of alternative educational media, contents, participants, and formats led to the conclusion that public television is an ideal initial medium for the effort. The aim of the TV programs is to provide background information on the nature of selected, major economic problems, to outline various proposals for alleviating them, and to explore considerations in the selection of alternatives. The programs are designed to be politically nonpartisan, balanced from conservative-liberal viewpoints, and neutral with regard to advocacy of alternatives.

The Forum was organized by the National Economists Club Educational Foundation and is supported by the National Science Foundation and various private foundations and corporations. NBER staff serve as members of the advisory board and panels and as program participants. Executive producer of the initial series is David Prowitt, Science Program Group, Inc., which is affiliated with National Public Affairs Center Television (NPACT).

The third in the series of programs was aired nationwide over the Public Broadcasting System's educational television network on December 3, 1974. This program, on *The Quality of Life*, featured Robert Dorfman, Harvard University; Irwin Halperin, Assistant Secretary for Policy Plans of the Department of Transportation; and Bert Seidman, Director of Social Security at the AFL-CIO, as expert commentators. It was preceded earlier in December by a show on medical economics—*The High Cost of Healing*, which featured Martin Feldstein, Harvard University; Victor Fuchs, NBER and Stanford University; and Philip Lee, University of California at San Francisco. The first program, *Inflation,* included a lively debate between Milton Friedman, NBER and University of Chicago; John Kenneth Galbraith, Harvard University; and Walter W. Heller, University of Minnesota and past Chairman of the NBER Board of Directors, and was aired over PBS in October.

All three programs were shown at the December 1974 Allied Social Science Association Meetings held in San Francisco. Plans are under way to have cassettes and films of these shows made available for classroom and other uses through the auspices of the Joint Council on Economic Education and other distributors. Funds are being sought to continue the series in fall 1975.

Gary Fromm

Progress Report—NBER-West

During the past year, NBER-West at Palo Alto, California, moved through the start-up stage to a fully functioning office of the National Bureau. The official inauguration took place on Sunday, September 29, 1974, with a joint Board of Directors-Staff meeting.

The new physical structure, the surrounding landscape, and the intellectual climate have each reinforced the basic research capability of the National Bureau. Within a year, the office has nearly reached capacity, based on a full-time staff, part-time researchers from surrounding universities, and a wide variety of visiting scholars (including Simon Kuznets, Harvard; Laurits Christensen, Wisconsin; and Victor Elias, Universidad Nacional de Tucuman, Argentina). On March 1, 1975, the roster of those engaged in research in the building included twenty-nine persons, with an additional twenty-eight engaged in projects administered from this office.

The office has hosted five one- and two-day conferences since it opened. Although minor logistical problems arose, the conferences appeared to be extremely successful. Most conferees were pleased with the facilities and working conditions. A maximum of sixty or seventy can probably be accommodated at one time, but the optimum ceiling is probably closer to fifty.

We have also had an extremely successful series of weekly seminars presented by our own staff, visiting scholars, and others from the Bay area. The research projects under way are reported under their individual topics in the staff projects reports section.

Victor R. Fuchs
Sherman J. Maisel

Research Fellowships

The National Bureau's research fellowship program is intended to provide additional educational opportunities to scholars of outstanding promise, generally at an early post-doctoral

stage of their careers. The fellows devote full time, usually for a year, to their research interests with access to Bureau facilities and in association with members of the Research Staff who are experienced in empirical research and who often are very familiar with the problems being investigated. The nature of the fellow's research interests generally determines which of the National Bureau offices is most appropriate for his work.

The current program has two phases. One, which dates back to 1930, is aimed primarily at scholars in the United States. The second, begun in 1972 with the support of the Rockefeller Foundation, brings to the Bureau promising young research fellows from universities in Africa, Asia, and Latin America.

Research fellows for 1974–1975 included Michael R. Darby of the University of California, Los Angeles, who was designated as the Harry Scherman Research Fellow and who spent the year at the Bureau's New York office; Mark V. Pauly of Northwestern University, who was at NBER-West in Palo Alto; and Robert J. Shiller of the University of Minnesota, who was at the Computer Research Center in Cambridge. Reports on their research are included in the present volume: Darby on "Macroeconomic Consumption" and "Qualitative Information and Market Structure"; Pauly on "The Effects of Physicians on the Demand for and Supply of Medical Care"; and Shiller on "Time Series Analysis Applied to Interest Rate and Price Data."

For 1975–1976 the research fellows are Donald O. Parsons of Ohio State University and Daniel L. Rubinfeld of the University of Michi-gan. Parsons, the new Harry Scherman Research Fellow for the year, intends to continue his work on human capital, including intergenerational relationships and family and market decisions. He will work at the Center for the Economic Analysis of Human Behavior and Social Institutions at NBER-West. Rubinfeld intends to study the effects of zoning and land use controls on urban property values at the Cambridge office in association with the urban studies staff and the Computer Research Center.

Patricio Meller, of the School of Economics, Catholic University of Chile, began his year as visiting foreign research fellow at the National Bureau's New York office in February 1975. He is investigating production functions and efficiency frontiers for Chilean industrial establishments of different sizes. Romeo M. Bautista, University of The Philippines, has also been appointed a foreign research fellow. He began his year's visit at the New York office in July 1975 and is studying the economic effects of international currency realignments on The Philippines.

Foreign research fellowships have also been awarded to two professors at Thammasat University, Bangkok. Oey Astra Meesook is expected to begin her fellowship year in October 1975 at NBER-West, continuing her research on income distribution in Thailand and other south Asian countries. Narongchai Akrasanee is scheduled to undertake his fellowship at the New York office in early 1976. His research interests are in trade and industrialization in Thailand and economic relations among Pacific Basin countries.

Douglas H. Eldridge