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**Staff Reports
on Research
Under Way**

1. ECONOMIC AND SOCIAL PERFORMANCE**Prices and Productivity****Introduction**

This program covers both measurement and analysis in two traditional areas of National Bureau interest: prices and productivity. Among the studies described below, those by Gordon and Ruggles are focused on measurement, that is, the improvement of measures of price change and the development of new ones. The other studies of prices and productivity are essentially analytical, although some new measures may be developed to aid in this task.

Two new projects are described below, one on foreign influences on input costs and manufacturing prices by Phillip Cagan and one on the wholesale price index by Richard Ruggles. The studies on inflation, 1964–1974, by Avram Kiselgoff and Joel Popkin, and research and development and firm productivity by M. Ishaq Nadiri, have been actively pursued during the year. Several others, begun earlier, are moving toward or through the publication process. One of these is Robert J. Gordon's volume on "The Measurement of Durable Goods Prices," which has been revised by the author after staff review and is now being updated. Phillip Cagan's study of the short-run behavior of prices was completed with the publication of "Changes in the Recession Behavior of Wholesale Prices in the 1920's and Post-World War II" and "Inflation and Market Structure, 1967–1973" in *Explorations in Economic Research*, Volume 2, Numbers 1 and 2 respectively, and the submission of a third paper for staff comment. M. Ishaq Nadiri's paper "The Behavior of Output and Input Prices," presented at the November 1974

meeting of the Conference on Research in Income and Wealth, will appear in the *Conference on Price Behavior, Studies in Income and Wealth*, Vol. 42 (forthcoming). A paper on his current study, reported on below, was presented at the November 1975 session of that conference on new developments in productivity measurement, and will be published in a forthcoming conference volume.

Several of the studies listed in this section are related to others described elsewhere in this report. The new project by Cagan will draw to some extent on the price data described by Kravis and Lipsey in the section on International Studies and will examine, from a different viewpoint, some of the same issues to be examined in the projected study of the international transmission of inflation through the world monetary system. Nadiri's study shares some data acquisition with the project on enterprise microdata, discussed in the section on the measurement of economic and social performance.

The program of research on productivity, employment, and price levels began under grants from the Sloan Foundation and the Alex C. Walker Educational and Charitable Foundation. The current work is being financed by the National Science Foundation, the Treasury Department, and the Council on Wage and Price Stability.

Robert E. Lipsey

Inflation Study

The objective of this study, financed by the National Science Foundation, is to contribute to the understanding of the causes of the inflation of

1964–1974 and of the ways the inflation affected the economy during this period.

The research results obtained thus far will be presented in papers at three professional society meetings. The comments received plus subsequent results of this research effort will form the basis for comprehensive analytical papers that will be submitted for publication.

Two of the three papers are concerned with sectoral analysis of inflation. In one the author discusses the behavior of crude oil prices and their effect on end-use prices of refined petroleum products. In the other the author examines the behavior of prices in manufacturing industries producing primary products (other than fuel). Price increases in both of these sectors together with those for farm products have been associated, causally by many, with the sharp acceleration in the U.S. inflation rate in 1973–1974.

The third paper is a progress report on a macroeconometric model of the U.S. economy in which the behavior of prices, output, and related variables for the intermediate sector of the economy are integrated with that of final demand components. The equation structure for the final demand sector of the model is that of the typical Keynesian model with three exceptions. First, the commodity portion of personal consumption expenditures is disaggregated differently to make the subaggregates conform with the definitions used to form the various groupings of finished goods manufacturers that supply consumer goods to retailers. The second distinction is related to the determination of the deflators for the components of personal consumption expenditures. In the typical models such deflators are functions of the overall deflator. In this model each deflator is explained, in part by indexes of manufacturers' prices for the particular commodity groups, and the deflators are then combined to form the total. The third distinction is that there is no overall equation for inventory change. It is derived instead from equations explaining inventory change in each of the various manufacturing and trade sectors.

The final demand and intermediate commodity producing sectors interact in the following way. For any grouping of final goods—con-

sumer home goods for example—final demand, prices, and the difference between actual and desired inventories determine orders placed with manufacturers. The level of manufacturers' production, finished goods inventories, and unfilled orders are then determined by using models based on linear decision rules. These decisions in turn affect inventory-sales, unfilled orders-sales, and capacity utilization ratios which, together with labor costs and materials input prices, enter the equation for manufacturers' prices. This process is repeated backward through the stages of process.

Results obtained to date indicate that the weakest link in the chain is the set of equations for orders. The inherent triangularity of the basic input-output table underlying the classification of sectors is used to attribute data available on orders received to the sectors placing the orders. More work is required with existing data to improve this link if the model is to be fully simultaneous.

The analysis of the behavior of primary industrial prices focuses on those industries that perform the initial processing of nonfood agricultural commodities, forestry products, and minerals other than fuels. They are disaggregated into eight groups: textiles, lumber, paper, chemicals, fertilizers, stone, clay and glass, iron and steel, and nonferrous metals. Preliminary results show that excess demand variables have significant, though often small, influences in six of these eight industries. In five of the six industries at least two of the three excess demand variables—unfilled orders, finished goods inventories and capacity utilization—are significant. This suggests that no one of these variables incorporates all the aspects of excess demand. This helps explain why, despite the fact that capacity utilization was no higher in 1973–1974 than in 1965–1966, price increases in these industries averaged much higher in the later period. In 1965–1966 a high level of capacity utilization was adequate to fill incoming orders without requiring any substantial buildup in unfilled orders or draw-down of finished goods inventories. In 1973–1974 that was not the case—unfilled orders rose and finished goods inventories fell, both markedly.

The price equations for these eight sectors,

when integrated with the equations for production, finished goods inventories, and unfilled orders, form a submodel that can be simulated under various assumptions about new orders received. This may explain the conditions in which bottlenecks occur and forewarn of any recurrence of the 1973–1974 explosion in prices of these primary commodities.

As a part of the study of the impact of “external” shocks on the overall rate of inflation in the U.S., special consideration was given to price behavior at the various levels of activity in the oil industry. Despite the considerable literature on the industry, there was no systematic set of data measuring prices at the various stages of processing and at the end-use level. By using various sources—government, industry, and consumers—it was possible to develop a reasonably reliable set of price data that could be used to study the propagation of price changes through the industry and its effect on the overall rate of inflation.

Table II-1 gives a general idea of price behavior over time for the last four Census years at the three major levels of the industry’s activity—crude oil production, refining, and distribution. An effort has been made to develop annual prices between Census years and to update this information through 1974.

The industrial sector models developed in this project will be used to study the more recent price behavior. Attention will be directed to determining whether the price behavior during the 1972–1974 expansion, the 1974–1975 contraction and 1975–1976 recovery can be generated

by the same structural model. The extent and timing of the transmission of price change since 1972 from one industrial sector to another will also be analyzed. The Council on Wage and Price Stability provided support for this project.

Avram Kisselgoff
Joel Popkin

Research and Development and Firm Productivity

The purpose of this research is to find the relationship between R & D activities and productivity at the level of the individual firm. A dynamic model of the determinants of investment, employment and R & D has been developed and estimated using data for individual firms. The specific questions considered are:

1. How do R & D activities fit in 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 research and development activities? In what way does the factor endowment of a firm affect its R & D intensity?
3. What are the dynamic adjustment processes 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 contrast with the long-run impacts of prices and

TABLE II-1

Preliminary Estimates of the Average Value of a Barrel of Oil at the Well, at the Refinery, and at the End-Use Level

| | 1958 | 1963 | 1967 | 1972 |
|---|------|------|-------|-------|
| Crude oil at the well | 3.01 | 2.89 | 2.92 | 3.39 |
| Finished petroleum (shipped) at the refinery level (f.o.b.) | 4.38 | 4.14 | 4.42 | 4.75 |
| Finished petroleum products at the end-use level excluding all direct taxes | 7.50 | 7.47 | 8.35 | 8.99 |
| Finished petroleum products at the end-use level including all direct taxes | 9.20 | 9.47 | 10.39 | 11.40 |

Note: Figures indicate average value per barrel in dollars.

sales on factors including R & D activities?

To analyze these issues, an interrelated factor demand model is derived from a cost minimization principle; its dynamic feature is that it traces the interaction of the adjustment paths of R & D investment, capital stock, and total employment. 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 labor productivity indexes for each firm and to examine the transitory and long-run responses of these indexes to changes in exogenous variables.

In estimating the model we have compiled the necessary data for approximately 90 companies for the period 1962–1974. The appropriate variables have been assembled by merging data from various sources, including supplemental data on costs of R & D personnel, prices of capital goods, and relative input prices obtained from the U.S. Department of Commerce. Information on some alternative indexes of innovative activities such as patents has also been assembled. The model has been fitted to the data for a sample of 62 firms for the period 1965–1974 and the results support the specification of the model. A paper based on these results will be published in the Conference on Research in Income and Wealth volume on "New Developments in Productivity Measurement." The main findings of this paper are:

1. The firm's employment, capital accumulation, and research and development decisions are closely intertwined and a dynamic interaction process seems to underlie these decisions.

2. As in the case of demand for labor and capital, the research and development activities of the firm are significantly influenced by both sales and relative input prices.

3. The long-run output elasticities of the inputs, especially those of labor and research and development, are quite similar and suggest a constant return to scale in production.

4. Both labor productivity and investment demand of the firms are significantly affected by

their research and development expenditures, and labor productivity is significantly affected by capital accumulation.

5. The demands for the three inputs are quite stable when firms are stratified by size of their assets; however, there is evidence of cross-sectional differences among firms and some changes over time in their input decisions.

Currently we are updating the data base and will test the stability and performance of the model for the larger set of firms.

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

M. Ishaq Nadiri

The Wholesale Price Index

A reexamination of the wholesale price index has been undertaken with the support of the Council on Wage and Price Stability and the cooperation of the Bureau of Labor Statistics.

The analysis is focused on the scope and coverage of the index, the classification structure and weighting system, the representativeness and/or redundancy of price observations, and the consistency and validity of price measurements.

The scope and coverage will be examined in terms of the requirements for monitoring price behavior, indexing of contracts, deflation of current price data, and the analysis of inflation. The classification structure and weighting system are important in determining how well the index is able to provide a summary measure of average price change and the relevant information on changes in relative prices in different sectors of the economy. The representativeness and/or redundancy of price observations refers to sampling design and the problem of ensuring reliable coverage at minimum cost. Bruce Spencer of Yale University is conducting the research in this area. Finally, the question of consistency and validity asks whether the index measures what it is supposed to measure and how it is related to other kinds of economic data.

Meetings have been held with federal government agencies that use the wholesale price index and with an advisory committee consisting of NBER staff members working in related areas. John LeMonnier is compiling materials generated by past NBER projects in this area and

Matthew Goldberg and Orin Hansen are providing data processing support. The Bureau of Labor Statistics is supplying the necessary detailed data to make this study possible.

Richard Ruggles

Foreign Influences on Input Costs and Manufacturing Prices

Due to the large increases in basic commodity prices in 1973 and 1974, public attention was focused on the influence of world price increases on domestic inflation. To what extent and how rapidly do such increases feed into domestic manufacturing costs and raise output prices? Do increases and decreases have symmetrical effects? Do changes in input prices that are usually more volatile have less effect or a slower effect on output prices than changes in input prices that are usually less volatile, because buyers are not sure whether the changes are permanent and are reluctant to respond to reversible price changes? Such differences in the transmission of changes in costs through the price system are relevant to the understanding and prediction of the domestic effect of world price movements.

The present study is a detailed empirical analysis of manufacturing input and output prices since the mid-1960's with special attention to the 1973-1975 period. Monthly input materials price indexes for the 50-odd input-output manufacturing industries are being constructed. Previously available indexes have been annual series or pertained to broader industry aggregates. Also, previous indexes have not been purged of overlapping components between input and output prices, leading to spurious correlation in price equations. The new series delete any common components between input and output series. This process reduces the coverage somewhat, but avoids serious problems in interpreting regression results. The new series will be used in price equations incorporating output and wage indexes for each sector. Inputs will be segregated according to the percentage of the total supply which is imported or exported. In that way we can study whether differences among inputs in their effects on output prices are related to the degree to which the inputs are world-traded. The price equations will

help to show to what extent particular cost increases are in fact passed through or are blunted, either by substitutions among inputs or other offsets.

Most of the data construction will be completed by late spring after which the analysis can begin. One of the advantages of the input-output framework is that particular cost increases can be traced through the price system from sector to sector. On the assumption that the coefficients for each sector do not change, the total effect on manufacturing prices of exchange-rate depreciation or oil-price increases can thus be calculated.

This study has been partially funded through a contract with the U.S. Department of Labor and the U.S. Department of the Treasury.

Phillip Cagan

The Measurement of Durable Goods Prices

The manuscript, summarized in previous progress reports, has been in revision during the past year, both to take account of suggestions from the NBER reading committee, and to update the results to include the 1970's. Contrary to my initial conjectures, the preliminary results indicate that the quality-adjusted prices compiled from the Sears Roebuck catalog have continued to increase at a slower rate than the comparable WPI indexes, diverging at roughly the same rate as during the 1960's. Work is now under way to update all possible indexes to the end of 1975, to allow study of the full period of the unwinding of price controls and of the 1974-1975 recession.

The Sears specifications have been studied very carefully in an attempt to find evidence of quality deterioration during the period of the price controls, 1971-1974. Thus far no evidence of quality deterioration in the form of "stripping" features from models has been found. There does appear to have been some thinning out of product lines, with fewer separate models available for each product, but this continues a trend that was apparent in the late 1960's.

In addition to the data collected from the Sears catalog, the manuscript is also based on hedonic regressions of used automobile and tractor prices, unit value indexes, and other sources. As many as possible of these sources

are being extended to 1975. While the extra work on data collection has delayed the appearance of the book, the opportunity to study the behavior of transaction price proxies during the most severe postwar recession should make the delay a worthwhile investment.

Robert J. Gordon

Measurement of Economic and Social Performance

Introduction

This project, funded by the National Science Foundation, has as its aim the extension of national economic accounts to provide better measurements of economic and social performance. Two types of extensions are being undertaken. First, at the macro level, non-market activities, the environment, and total income measurement are introduced into the national accounts in order to make them more comprehensive. Second, at the micro level, data sets for households, enterprises and governments are developed in a form that will fit into the sectors established in the macroeconomic data. Such microdata sets will make it possible to introduce social, demographic, and locational information into the extended national accounting system. The MESP project has been organized into subprojects, each with its own principal investigators, as follows:

1. National Economic Accounts
 - A. The extended national accounting system
Richard Ruggles and Charlotte Boschan
 - B. Nonmarket economic activity
John Kendrick
 - C. Total income measurement
Robert Eisner
 - D. National accounting and the environment
Henry Peskin
2. Microdata Sets for the National Accounts
 - A. Household microdata sets
Richard Ruggles and Edward Wolff
 - B. Lifetime income patterns of individuals
Milton Moss
 - C. Enterprise microdata sets
Robert Lipsey and Michael Gort
 - D. Government microdata sets
John Quigley

In the research on national economic accounts Richard Ruggles and Charlotte Boschan are concerned with developing the economic accounting framework that will be used as the basis for integrating the subprojects of MESP as well as the various kinds of economic accounting data that exist in the Federal government. The work 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 nonmarket 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 nonmarket 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 is also continuing. Richard Ruggles, Milton Moss, and Edward Wolff are concerned with the household sector. Richard Ruggles is developing a macro household sector account that excludes nonprofit institutions, to which the microdata set for households can be aligned. Edward Wolff has completed some of the actual merging of a number of different microdata sets using the techniques developed in the pilot project, and is continuing this work. He is also endeavoring to develop balance sheets for each household in the microdata set. Milton Moss is using cohort data 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. The development of a microdata set for the government sector 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 types of expenditures of different governmental units by geographical area. Finally, Thomas Juster at the Institute for Social Research at the University of Michigan is completing his 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.

Richard Ruggles

The Extended National Economic Accounting System

In order to provide a framework for the extensions of the macroeconomic accounts being generated by MESP subprojects, and the sectoring and economic constructs required for the microdata sets, an expanded system of national economic accounts is required. The basic system being developed was contained in a report "The Measurement of Economic and Social Performance: A Progress Report on a National Bureau of Economic Research Project" presented at the Fourteenth General Conference of the International Association for Research in Income and Wealth held in Aulanko, Finland, in August 1975.

An effort is now being made to utilize the flow of funds data of the Federal Reserve Board together with the newly revised data on the national income accounts of the Department of Commerce as the basis of the extended system of accounts. The NBER data bank is being used to generate the required national income accounting data in a suitable machine readable form that is compatible with the flow of funds data provided by the Federal Reserve Board. This set of the combined data and additional estimates provided by the other MESP subprojects will be used to generate an integrated and extended set of sector accounts. Richard Kjetsaa is working on the matching and coding of income flows. Bruce Margolin is writing the programs necessary to generate the extended accounts.

Richard Ruggles
Charlotte Boschan

Nonmarket Economic Activity

During the past year, we have virtually completed the revision and extension through 1973

TABLE II-2
Adjustments of Commerce Department Estimates of GNP for
Consistency with Total Investment and Capital Estimates
(billions of dollars)

| | 1969 | 1973 |
|--|--------------------|---------|
| Current dollars: | | |
| GNP, commerce concept | 929.1 ¹ | 1,294.9 |
| Plus: | | |
| Personal sector imputations: | | |
| Student compensation | 92.3 | 148.1 |
| Fractional unemployment | 16.0 | 24.1 |
| Rentals on household capital | 100.1 | 138.5 |
| Rentals on institutional capital | 5.7 | 8.5 |
| Business: Investments charged to current account: | | |
| Tangible | 2.3 | 3.3 |
| Intangible | 35.4 | 45.6 |
| General governments: Imputed rentals on public capital | 67.0 | 91.2 |
| Equals: Adjusted GNP | 1,247.9 | 1,754.3 |
| Ratio to Commerce GNP | 1.343 | 1.355 |
| Constant 1958 dollars: | | |
| Commerce GNP | 724.7 | 839.2 |
| Adjusted GNP | 957.2 | 1,104.5 |
| Ratio | 1.321 | 1.316 |

SOURCE: "Economic Growth and Capital Formation," Subcommittee on Economic Growth of the Joint Economic Committee of Congress, February 1976.

1. The Commerce Department estimate of GNP for 1969 was subsequently revised slightly upward from the number shown here which is consistent with the adjusted GNP series for the period 1929-1969 presented in John W. Kendrick, *The Formation and Stocks of Total Capital*. (New York: National Bureau of Economic Research, 1976.)

of estimates of the imputed values of nonmarket economic activity. Some of the imputations, together with extensions through 1973 of the estimates of the formation and stocks of total capital, by sector and type, were published in February 1976 by the Subcommittee on Economic Growth of the Joint Economic Committee of Congress in a pamphlet entitled "Economic Growth and Total Capital Formation." The relevant table from that publication is reproduced in Table II-2. It will be noted that the current dollar estimates show a continuation of the upward trend in the ratio of imputed values of nonmarket transactions to GNP between 1969 and 1973. In constant dollars, however, the ratio leveled out.

The chief items not included in the table are the values of unpaid household services, and business-financed consumption charged to current expense. Further work is being done on these items, particularly the imputed values of household services that Richard Ruggles is integrating into microdata sets for the personal sector. Estimates are being reworked for consistency with the revised GNP estimates that appeared in the January 1976 *Survey of Current Business*, including conversion of the constant dollar estimates to a 1972 price base.

John W. Kendrick

Total Income Measurement

Preliminary trial balances of the Total Incomes System of Accounts (TISA) for 1959 and 1969 have been completed. These involve sectoral estimates of income and product for business enterprises, government enterprises, nonprofit institutions, government, and households. Imputations have been gathered or produced for a variety of nonmarket economic activities such as child rearing, the full cost of education and training, including opportunity costs of students 14 years of age and over, the services of volunteers, and the full value of services of those drafted for military and jury duties. Estimates are offered of income and product attributable to all capital, tangible and intangible, in government and households as well as in business. Consumer goods not used up within a year are capitalized and only their services are counted in current consumption and production.

A number of items have been reclassified. Much of government product, particularly military and police services, has been categorized as intermediate rather than final in character. Commuting or transportation services as well as some other expenses related to work have also been classified as intermediate. On the other hand, media services and certain business expenses or expenditures involving additions to consumer welfare have been counted as final output.

As a major innovation, "net revaluations" of tangible and intangible capital were included in income. These are defined as changes in the value of capital stock minus the net investment that has occurred and that portion of the increase in the money value of capital stock related to general price increases. Net revaluations thus are the money value of real capital accumulation, that is, increases in the money value of capital, beyond that necessary to keep its real value intact, which have not been accounted for as net investment.

Capital consumption, involving all capital, tangible and intangible, relates to the current value rather than the original cost of capital. In estimates we have generally taken straight-line depreciation to be the best measure of the path of decline in value of capital over time when revaluations are accounted for separately. Ultimately, wherever possible, we intend to estimate consumption of capital as the decline, occasioned by the passage of time, in the present value of its forthcoming future services. We have also altered the conventional treatment of indirect business taxes by introducing "net indirect enterprise taxes." This entails a subtraction of intermediate product transferred from government. As a further effort to derive a value of total production not necessarily tied to market prices and transactions, the value of subsidies as well as uncompensated factor services is included in TISA national product. A complete outline of the set of accounts along with a general discussion of the conceptual framework has been offered in "TISA: The Total Incomes System of Accounts," presented to the Fourteenth General Conference of the International Association for Research in Income and Wealth, Aulanko, Finland, August 1975.

Preliminary trial estimates of TISA national product came to approximately \$845 billion for 1959 and \$1,574 billion for 1969. These were 74.5 percent and 69.2 percent, respectively, above the Bureau of Economic Analysis estimates of conventional gross national product for those years. The largest single element in the differences, amounting to close to half of their magnitudes, is unpaid household work. Imputations of income and product for the opportunity costs of students were also significant items. Estimates of net revaluations were in the neighborhood of +\$30 billion in each year, but are entirely tentative in character. They are included at this point in an effort to complete a trial set of accounts rather than on the basis of application of appropriate procedures to an adequate set of data. A major remaining difference between TISA and BEA estimates relates to expanded capital consumption allowances, that reflect our vastly more extensive categories of capital. The TISA estimates of net national income were \$600 billion in 1959 and \$1,156 billion in 1969, exceeding the corresponding BEA national income estimates for those years by 50.0 percent and 50.9 percent.

The current estimates have largely been prepared by Augustine Fosu, business accounts; John Graham, government accounts, including special estimates of normally unmeasured product of jurors and military draftees; and Roy Webb, who has worked primarily on the household and nonprofit institution sectors. To a major extent we have relied upon data taken from the work of John Kendrick, including estimates from his book *The Formation and Stocks of Total Capital*, New York, National Bureau of Economic Research, 1976.

In related work, John Graham and Roy Webb have estimated life-time earnings for United States males, utilizing public use sample tapes. They have brought together information from successive cross-sections to project cohort earnings of various educational groups. By utilizing earnings rather than total income, and adjusting for evidence of differential rates of growth of earnings over time, Graham and Webb have arrived at unique estimates of human capital as the present value of projected future earnings. Their approach indicated paths of depreci-

ation of human capital that suggest growth in the value of individuals' human capital initially, that is, negative depreciation followed by relatively slow depreciation in later years. The work of Graham and Webb will be reported upon in a paper entitled "Present Value Estimates of Human Capital Stocks."

Ronald Rost has been studying the impact of pollution abatement investment (PAI) on factor productivity. Preliminary results suggest a statistically significant decline in the capacity-capital ratio of manufacturing that has been related to anti-pollution efforts. Current research into two-digit private nonfarm industries is aimed at determining the extent to which recent slow-downs in the growth of labor productivity can be attributed to the growth of pollution abatement investment that does not contribute to usual measures of market output.

Such substitution of environmental protection or improvement for market output affects the value of both physical and human capital stocks. A conceptual framework is being developed to link pollution-abatement induced changes in productivity to resulting capital gains and losses. Where possible, estimates of effects on factor productivity will be fitted into this framework.

Other work in process and in prospect includes an attempt by Fosu to revalue human capital on the basis of estimates of total labor services rather than merely direct returns to labor. The latter may underestimate the contribution of human capital to production in the presence of fixed employment costs which cause a deviation between the marginal product of labor and payments for labor services.

Graham plans to study the composition of assets and saving over the life cycle of the individual utilizing our expanded concepts of capital and output. Saving is to be defined as the change in net worth, or in the purchasing power of net worth, and is to include all types of financial assets, tangible assets such as households' durables and residential structures, and the intangible assets of human capital such as education, training, and health. It is noted that, especially early in life, individuals accumulate substantial portions of their net worth by investing in their own intangible capital. They accumulate a variety of assets, yielding a variety of returns,

in the interest of attaining optimal combinations of risk and liquidity as well as earnings. Theories of asset composition will be developed in a dynamic context and tested with a microeconomic data base.

Roy Webb will study the influence of inflation on stability of relative prices and, consequently, transaction costs. Estimates of income and wealth effects of possibly increased transaction costs will be sought in the behavior of consumers and producers. It may prove useful to regard knowledge of relative prices as an intangible capital stock and to investigate the effect of inflation on the value and rate of depreciation of this stock.

A paper "Income and Capital Gains," is to be presented at the Conference on The Measurement of Capital sponsored by the Conference on Income and Wealth of the National Bureau of Economic Research in October 1976 in Toronto.

Robert Eisner

National Accounting and the Environment

During the past year, work on this project, whose purpose is to include imputed values of the services of environmental assets and pollution damage in the national accounts framework, has focused on the development of water pollution control costs. (These costs will be used as a first approximation of the value of water for waste disposal purposes.)

There are several reasons why this task proved formidable. In the first place, most of the available cost estimates are for industries that are not defined according to the SIC. Often a rather detailed examination of the underlying costing documents was required to untangle and reassign the estimates to appropriate SIC's. Secondly, there is a lack of consistency in defining cost components, especially when pollution-reduction techniques involve extensive use of land. There is also a bothersome inconsistency between cost estimates pertaining to the same industry, but published by different sources. Resolving these inconsistencies often requires step-by-step replication of the various costing methods.

Undertaking these replications revealed another problem: often these methods depend on questionable assumptions. Therefore, when data

permitted, these estimates were recomputed using, we believe, more realistic assumptions. Finally, there are many data gaps. Undercounting the number of establishments within industries and total neglect of certain other industries are two reasons for less than complete coverage.

Because of their interest in more accurate cost data, the U.S. Environmental Protection Agency provided partial financial support for this costing effort.

Research has also been directed toward developing improved methods for converting total cost (or damage) estimates to marginal ("price-times-quantity") estimates. The approximation procedure we had originally suggested for doing this is valid only when costs (or damage) depend on a single variable. Since most of our cost information associates cost with the reduction of several pollutants, it was necessary to develop a multivariable generalization of our original approach.

In August 1975, a brief overview of the project was presented at the Income and Wealth Conference in Aulanko, Finland. This talk was based on a paper published in the September 1975 volume of *Social Indicators Research*. Another paper discussing the theoretical framework of the environmental accounts was accepted by the *Journal of Environmental Economics and Management* and will be published in Volume 3, No. 1.

Henry M. Peskin
Leonard P. Gianessi

Household Microdata Sets

The development of techniques of matching different samples of household data has been one of the major concerns of the subproject on household microdata sets. An article describing the techniques of matching appeared in the *Annals of Economic and Social Measurement*, Vol. 3, No. 2. The computer programs needed to carry out statistical matches have all been written and are in use. The research effort is now focused on developing the household microdata sets more fully. At the present time imputations for time use of individuals in households are based on existing information; during the summer the data that are being developed by the

Survey Research Center in collaboration with the MESP project will be used to provide a better basis for estimation of nonmarket activity of households.

The development of balance sheets for households at the micro level is being undertaken to provide information on the distribution of wealth by economic and social groups. The estimation of balance sheets entails the valuation of household durables and the capitalization of financial flows. Three statistical matches are necessary before the imputations can be performed. The first is the match of the 1970 Internal Revenue Service (IRS) Tax File to the 1969 IRS Tax File. This has been completed. The second is the match of the 1969–1970 IRS Files to the 1970 Census 1/1000 5 percent Public Use Sample (PUS). This match is now underway. The third is the match of the 1970 15 percent PUS to the 1970 5 percent PUS. This is due for completion in November of this year.

Concurrently, preliminary work on the valuation of durable consumer goods has almost been completed. In order to analyze the relation between household expenditures on durables and demographic characteristics, we have used the 1960–1961 Bureau of Labor Statistics Consumer Expenditures Survey. In addition, a program is now being designed which will assign purchase price, age, and current market value to each durable good listed in a household's inventory.

Finally, a study on the effect of demographic factors on the inequality of earnings within occupations is close to completion. The data bases employed for this study were the 1960 and 1970 Census 1/1000 Public Use Samples. For each of 295 occupations in 1960 and 439 in 1970, a sample of approximately 200 occupational members was randomly selected. For each occupation we computed the coefficient of variation of earnings, mean earnings, the mean and standard deviation of hours worked, the mean and standard deviation of age and education, an interactive age-education variable, the urban-rural mix, the industrial mix, and the race and sex compositions. The coefficient of variation was regressed on the other variables across all occupations and across occupations in five major sub-groups: professional; technical and

managerial; clerical and sales; skilled and craft; semiskilled and operatives; and service and unskilled. Our preliminary findings were as follows. (1) Differences in hours worked are a significant determinant of inequality in all occupations and in each of the sub-groups. (2) Differences in age and educational composition explain a large part of the variations in earnings inequality among all occupations taken together and among professional and clerical occupations, but are insignificant determinants of inequality among skilled, semi-skilled and unskilled occupations. (3) The industrial and urban-rural mix variables, which we regard as indexes of alternative employment opportunities, have significant coefficients for all occupations and most sub-groups. (4) Sex and race composition variables have insignificant coefficients, suggesting that discrimination takes the form of occupational segregation rather than pay differentials within occupations.

Richard Ruggles
Edward Wolff

Lifetime Income Patterns of Individuals

The NBER inquiry on lifetime income, which is one of several parts of the study on the Measurement of Economic and Social Performance funded by the National Science Foundation, has two objectives: (1) to demonstrate the importance, within the National Economic Accounts, of viewing the changing distribution of total personal income on the basis of a distribution of lifetime income, and (2) to use lifetime income as a major illustration of, or first step towards, a broader study of social change as seen in a lifetime framework.

The emphasis in this study is mainly on the change in income over time. For this purpose, longitudinal data over extended periods of the life span are required. Our best approximation to such panel data, at this stage, is mainly birth-cohort data. We have also utilized some longitudinal data mainly from the Longitudinal Employer-Employee Data File of the Social Security Administration.

We have derived the average income experience of cohorts in the 25-year period 1947–1972 by calculating the average percentage changes

in real income over 10-year spans starting at age 25–34 for as many cohorts as possible in the 1947–1972 period. With the economic growth and mild inflation then prevailing, income continued to rise on the average through the life cycle until retirement. If growth had not been present, income as measured would have leveled off around age 40 and would have declined more sharply after retirement. Based on the 1947–1972 experience, about 60 percent of the total income expected after age 25–34 was due to general economic growth.

Since 1972 or so we have been witnessing a sharp abatement in economic growth, no doubt in part cyclical. If a secular decline in the rate of growth occurs, then expectations of future income at all stages of life and for all current generations will be scaled down accordingly, and would in turn affect consumption, savings, and rates of return on human investment.

We have explored further the phenomenon of changing inequality of income within birth cohorts as they age. Dispersion is shown to increase for the cohorts we have been able to study. The increase in dispersion diminishes with age, but as far as we could determine, persists even beyond retirement.

Inter-cohort comparisons have involved two aspects. The first, in which time periods have been varied but age held constant, essentially measures economic growth for specific ages. We have confirmed the finding that age-specific growth rates in income tend to be equal across ages. The second involves holding the time period constant to show the changing age levels at which successive cohorts achieve a given level of income measured in constant prices.

In our analysis of income by source, we have made progress on the age-income profile for property income. Recent cross-sections show a constant rate of increase with age in contrast to the declining rate for earnings. Dispersion in property income tends to increase with age.

Milton Moss
Jane Duberg

A Microdata Set for Enterprises

Work has been proceeding along two lines in this project. One is to develop information for

companies, combining data from several different sources, and another is to develop information for individual establishments that will be linked to the company data.

There are a number of sources of company data essentially based on reports to stockholders or to the SEC. One problem with the available sources, from our point of view, is that companies which disappear, by merger or bankruptcy, are dropped from compilations for their whole lives, not only for the period after their disappearance. Therefore, the current version of a financial data tape, such as Standard and Poor's Compustat tape, will have less complete coverage of a period ten years ago than of the latest year. We are constructing a financial data tape that will include companies that later disappeared, and will thus cover a more fixed (and larger) part of the corporate universe.

The major part of our effort is to construct a data set for establishments as of approximately 1972. We have acquired two private compilations of establishment data on employment in manufacturing that we plan to combine into a data set which will give employment for each of more than 350,000 establishments, identified by parent company, location (county, and in most cases, address), and industry. We have been sorting and aligning the two compilations and comparing them, by industry and state, to the *1972 Census of Manufactures*. The results have been encouraging, indicating that it should be possible, by combining the two sources, to achieve coverage greater than 95 percent on the average.

For those firms that are in the company data set we shall construct, from the establishment data, distributions of their employment by industry and location, as we did on a smaller scale for 1970. These should be analytically more useful than the usual assignment of a firm to one industry, which in many cases will represent a minority of the firm's employment.

In addition, an attempt is being made to develop data on the occupational skill composition, and the racial and sex composition, of the employees of large and medium-sized firms. To our knowledge this is the first time that microdata of this type have been combined with other company data such as financial information and

statistics on research expenditures, firm size, and the product mix of the relevant firms.

Our sample consists of 391 firms in 24 4-digit industries (with firms classified on the basis of the primary industries of the firms). These are drawn from the list of companies for which both financial data, and product data for establishments, are available. In addition to sex and race, the following skill breakdown will be available: officials and managers, professionals, technicians, sales workers, office clericals, craftsmen, operatives, laborers, service workers.

We hope to complete our initial corporate and establishment data sets within a few months. At that time we will have tested and explored the occupational and related employee characteristics data and can begin to merge them with the others.

Robert E. Lipsey
Michael Gort

Government Sector Data

This part of the MESP project involves a systematic attempt to disaggregate the government sector of the national accounts—to trace the fiscal linkages among the local, state, and federal levels of government and to provide quantitative estimates of the activities of these governmental units on a geographically disaggregated basis.

The data set consists of government sector accounts which conform, in general, to those currently maintained on a consolidated basis for all governments, but which are estimated separately at the county level. For lower levels of government, the revenue and expenditure accounts at the county level are derived principally from survey data collected by the U.S. Census: the census of government finances and the census of government employment. For the federal government, the analysis is designed so that estimates of receipts and expenditures by region can be facilitated under a wide variety of plausible incidence assumptions.

Preliminary findings, indicating the sources of federal government receipts at the state level, were presented in a paper prepared for the conference of the Society of Government Economists in April 1976.

John M. Quigley

Business Cycles

Introduction

The National Bureau has become, over the years, one of the nation's leading sources of information about business cycles. Probably the most widely used items are the chronology of peaks and troughs and the lists of leading, coincident, and lagging indicators. However, we are called upon also for historical and current data, computer programs for business cycle analysis, statistical measures such as leads and lags, and evaluations of data. Prompt, helpful, and responsible answers to inquiries have helped build the Bureau's reputation for useful, dependable information. So have our efforts to publish such information widely and to make it readily accessible on computers.

In the past we have treated such work largely as a by-product of research. However, the activity itself does employ resources, and unless they are explicitly provided, the activity is likely to be slighted and poorly done, in which case it may become more of a liability than an asset to the Bureau. Moreover, this type of activity is not likely to attract special grants of funds; it lacks glamor and seldom yields a tangible product. For these reasons specific plans for this work are being drafted to determine the funds required and to facilitate decisions regarding their use. They include the following activities:

1. Maintain, revise, and describe business cycle and growth cycle chronologies.
2. Tabulate and analyze the quarterly survey of economic forecasts conducted since 1968 in cooperation with the American Statistical Association.
3. Reevaluate specific indicators or lists of indicators.
4. Convert our historical data files and series descriptions, as well as certain standard cyclical measures for these series (leads and lags, amplitudes, conformity indexes) to machine-readable form.
5. Respond to inquiries for all of the above and issue reports or catalogs from time to time to make their availability known to potential users. In this connection we are considering issuing a quarterly Business Cycles Information

Report that would contain the forecast survey mentioned above, short articles based upon our business cycle studies, and tables or charts pertaining to some new results of our work.

The main content of the business cycle program has continued to be monographic studies of business cycle phenomena. The present list of studies, reported below, are simply examples from the broader spectrum that has been cultivated over the years. These studies have a feedback effect on the informational side of our work, since they require and develop expertise in particular fields, and provide new findings, new data series, etc. They also overlap on other fields at the National Bureau, especially the studies of productivity, employment and price levels, and financial institutions and processes.

A book by Geoffrey Moore with the tentative title "Business Cycles, Inflation, and Forecasting" is being prepared for publication. It will consist of some new articles in this field as well as updated versions of recently published articles. The Hoover Institution at Stanford University has agreed to collaborate with the National Bureau in the publication of this work. Some of the following articles, prepared during the year, will be considered for inclusion in the volume:

"Is Inflation Accelerating Again?," *The Conference Board Record*, March 1976.

"Employment and Unemployment—A Conundrum," *Morgan Guaranty Survey*, February 1976.

"Measuring Employment and Unemployment," *The World Almanac and Book of Facts*, 1976.

"The Numbers Aren't Everything," *New York Times*, October 2, 1975.

"Economic Indicators and Econometric Models," *Business Economics*, September 1975.

"The Federal Deficit as a Business Cycle Stabilizer," testimony before the Committee to Investigate a Balanced Federal Budget, Democratic Research Organization, Washington, D.C., March 25, 1976.

"Employment, Unemployment and the Inflation-Recession Dilemma," American Enterprise Institute, May 1976.

"Updating the Forecasting Record," in preparation.

"The Slowdown, Recession, and Recovery of 1973-1976," Victor Zarnowitz, co-author, in preparation.

Geoffrey H. Moore

Monetary Trends in the United States and United Kingdom, 1867-1973

During the past year we revised and extended backward the U.K. annual series underlying our study of trends and added the latest cyclical turns in both the U.S. and U.K. data. We now have 51 phase observations for the United States, 35 for the United Kingdom, with two fewer rate of change observations for each country. On the technical side, we experienced some delay in processing our data with the shift from the Yale to the Cornell computer, and the need to convert the programs on which we depend, from cards and a batch system to terminals and time-sharing in TSO and TROLL.

The main substantive accomplishment was the completion of a draft of the tenth chapter of our manuscript. The chapter deals with trends in money and interest rates. We first present statistical results bearing on a theoretical analysis that links changes in the quantity of money with interest rates. Three effects of changes in the quantity of money on interest rates are distinguished: a negative impact effect that includes the Keynesian liquidity effect and a first-round loanable funds effect; a positive intermediate effect as real income and prices respond to the monetary change; and a long-run price anticipations effect.

For each country we have data for a short-term market interest rate and a long-term bond yield (for the United States, corporate bond yields; for the United Kingdom, Consol yields). Our phase average data reflect at most only a muted impact effect of change in the quantity of money, but a stronger intermediate income effect.

To test for the presence of a price anticipations effect on interest rates, we examine not only the nominal yield on nominal assets, represented by the short-term market rate and the long-term bond yield, but also a measure of nominal yields on real assets. For this purpose, we used as a proxy the rate of change of

nominal income. The rate of change of nominal income is the sum of the rate of change of prices and the rate of change of output. The rate of change of prices may be regarded as a proxy for the change in market price of real assets. The rate of change of output may be regarded as an estimate of the real yield of real assets. Hence the rate of change of nominal income may be regarded as a proxy for the total nominal yield on real assets.

Our results reflect the existence of a relationship between the price level and yields on nominal assets—the Gibson paradox—and the absence of any Gibson paradox for nominal yields on real assets. For nominal yields on real assets, we observe a positive correlation between the rate of change of prices and the level of yields.

The contrast does not reflect prescience about price behavior by investors in real assets and ignorance about price behavior by investors in nominal assets. It simply reflects the contemporaneous effect of price change on the nominal yields of real assets. Prescience would be required of investors in nominal assets who fix rates in nominal terms and contract for a period ahead, if these rates were to reflect future price behavior.

Irving Fisher's explanation of the Gibson paradox was that people formed their anticipations as a weighted average of earlier price experience, lagging past prices some ten to thirty years, and implicitly assumed that they held *ex ante* real yields constant. Recent studies for the pre-World War II period cast doubt on the validity of the explanation because the *ex ante* real rate cannot be regarded as constant or because people formed price anticipations differently than Fisher assumed.

Our contribution to the issues involved in the Gibson paradox is a study of the difference between yields on nominal and on real assets in relation to price experience in the century our data cover. We have two periods of generally falling prices (pre-1896 and the interwar period), two wartime periods of rising prices, and two peacetime periods of rising prices (1896 to World War I, and the post-World War II period). If there were arbitrage, yields on nominal and real assets should be equal—or differ by a constant reflecting the average preference for real

versus nominal assets (or the reverse). Both would be lower in nominal terms during periods of falling prices than in periods of rising prices. Our data, however, show that in the two periods of falling prices, the yield on nominal assets is decidedly higher for both countries than the yield on real assets. Deflation was not anticipated. Lenders did well. Borrowers did poorly. Since entrepreneurs borrow in nominal terms to acquire real assets, it follows that in general rentiers did well, entrepreneurs badly.

With the exception of the United Kingdom after 1896, the relation is reversed during periods of inflation: yields on real assets are higher than yields on nominal assets. Inflation was not anticipated. Entrepreneurs did well, rentiers did poorly; capital was transferred from savers to borrowers.

If subperiods are listed by the rate of price change (as in Table II-3), disregarding both chronology and country and beginning with negative rates of price change and ending with the highest positive rates, we find that nominal yields (column 2) fluctuate about a roughly constant level, so that the effect of inflation is reflected primarily in a sharp decline in the real yield on nominal assets (column 4) (the nominal yield minus the rate of price change). The excess of the yield on real assets over that on nominal assets (column 6) is sharply negative for deflation, sharply positive for inflation. These results are inconsistent with the hypothesis of (a) a constant real rate, (b) correctly anticipated rates of inflation.

Suppose that nominal yields do not adjust to the actual rate of inflation, but along Fisher's lines do adjust to the anticipated rate of inflation, which in turn adjusts to actual inflation after a considerable lag. We would then expect to find that shortly after a change from, say, falling to rising prices, the yield on real assets would exceed considerably the yield on nominal assets, reflecting the incorporation in the yield on nominal assets of the lagged anticipations of falling prices. As prices continued to rise, the differential would decline and approach the equilibrium difference, reflecting any general preference for real over nominal assets (or conversely).

The post-World War II period is the first in

TABLE II-3

Difference Between Yields on Real and Nominal Assets,
Related to Level of Change of Prices

| Phase and Country | DP.A (1) | Nominal Yield on | | Real Yield on | | Excess of Yield on Real Assets over Yield on Nominal Assets | |
|-------------------|-------------|--------------------------------|-------------------------------|---------------------------------|--------------------------------|---|--|
| | | Nominal Assets RS (2) | Real Assets DI.A (3) | Nominal Assets RRS (4) | Real Assets DIP.A (5) | Nominal Yields Col. 3-Col. 2 (6) | Real Yields Col. 5-Col. 4 (7) |
| <i>Interwar</i> | | | | | | | |
| U.S. | -1.76 | 3.54 | 0.12 | 5.31 | 1.88 | -3.42 | -3.43 |
| U.K. | -1.69 | 3.06 | -0.33 | 4.74 | 1.35 | -3.39 | -3.39 |
| <i>Pre-1896</i> | | | | | | | |
| U.S. | -1.72 | 5.43 | 1.88 | 7.14 | 3.60 | -3.55 | -3.54 |
| U.K. | -0.65 | 2.60 | 1.39 | 3.25 | 2.05 | -1.21 | -1.20 |
| <i>1896-WWI</i> | | | | | | | |
| U.S. | 1.86 | 4.69 | 5.09 | 2.83 | 3.23 | +0.40 | +0.40 |
| U.K. | 0.68 | 3.26 | 2.12 | 2.58 | 1.44 | -1.14 | -1.14 |
| <i>Postwar</i> | | | | | | | |
| U.S. | 2.70 | 3.87 | 5.95 | 1.17 | 3.25 | +2.08 | +2.08 |
| U.K. | 4.07 | 4.94 | 6.49 | 0.87 | 2.42 | +1.55 | +1.55 |
| <i>WWII</i> | | | | | | | |
| U.S. | 5.91 | 0.82 | 8.95 | -5.09 | 3.04 | +8.13 | +8.13 |
| U.K. | 4.92 | 0.85 | 6.47 | -4.07 | 1.55 | +5.62 | +5.62 |
| <i>WWI</i> | | | | | | | |
| U.S. | 9.40 | 5.07 | 12.95 | -4.34 | 3.55 | +7.88 | +7.89 |
| U.K. | 15.12 | 4.33 | 12.10 | -10.79 | -3.02 | +7.77 | +7.77 |

Note:

DI.A = phase average computed from annual difference in log of nominal income.

DIP.A = phase average computed from annual difference in log of real output.

DP.A = phase average computed from annual difference in log of price level.

RS = phase average computed from annual average short-term market rate of interest.

RRS = phase average computed from annual average short-term market rate of interest minus annual difference in log of price level.

which we find more than a bare trace of the Fisherian pattern. For the United States, the differential generally falls during the postwar period of rising prices. More important, the differential is inversely rather than positively related to the rate of price change; the nominal asset yield is as variable as our proxy for the nominal yield on real assets; the nominal asset yield rises steadily throughout the period; the real yield on the nominal asset rises sharply in the early part of the period and then fluctuates at a more or less constant level; and our proxy for the real yield on real assets shows no steady trend. The United Kingdom results show an even

clearer tendency for the differential to decline, again reflecting a steady rise in the nominal asset yield, an initial sharp rise in ex post real yields on the nominal asset, and no steady trend in our proxy for the real yield on real assets.

The somewhat greater conformity of the evidence to Fisher's hypothesis in the post-World War II period, but not earlier, raises the problem of accounting for that result. An alternative to Fisher's explanation is that the Gibson phenomenon in principle reflects real forces that affect both prices and interest rates in the same direction. The correlation between nominal yields and prices then is simply a reflection of

real forces simultaneously affecting real yields and prices. So far as our data go, no explanation of the Gibson phenomenon for nominal yields that implies a similar phenomenon for real yields is acceptable. Only for the pre-World War I period is there a positive correlation between the rate of change of prices and ex post real yields, such as is implied by this alternative explanation.

Any explanation of the Gibson paradox in terms of the mode of formation of anticipations will presumably have to account for the difference between success of the Fisherian hypothesis for the post-World War II period and its failure for the earlier period. Our provisional conclusion is that no satisfactory explanation is forthcoming as yet in terms of the formation of anticipations.

Milton Friedman
Anna J. Schwartz

International Economic Indicators

When the International Economic Indicators project was launched in 1973, two initial questions posed were (1) could traditional NBER techniques, developed for classical cycles, be applied to dating growth cycles both in the U.S. and other market-oriented economies and (2) would reliable U.S. leading and lagging indicators of classical cycles perform equally well as leading and lagging indicators of growth cycle turning points in the U.S. and abroad? Classical cycles are the phases of economic expansion and contraction represented in the NBER's business cycle chronology; growth cycles are phases of more rapid and less rapid growth.

During the past year we have completed the initial analysis for five countries of data approximating, as closely as possible, the twenty-six series on the 1966 NBER list of indicators. This has enabled us to select comparable growth cycle turning points for the United States, Canada, the United Kingdom, West Germany and Japan. A preliminary analysis of the behavior of the indicators for the U.K. by Philip A. Klein was published in *Explorations in Economic Research*, Vol. 3, No. 1. In this study, "Postwar Growth Cycles in the United Kingdom: An In-

terim Report," Klein demonstrates the potential value of the indicators approach when applied to growth cycle analysis in other countries. Comparable studies for the other countries have now been completed and several reports have been prepared, including the following.

"Business Cycles in the Postwar World: Some Reflections on Recent Research," by Philip A. Klein, American Enterprise Institute, Washington, D.C., 1976.

"New International Business Cycle Indicators System: Applying the NBER Indicator Approach to International Growth Cycles," Office of Competitive Assessment, U.S. Department of Commerce, September 1975.

"Impact on U.S. Trade Performance of Business Cycle Movements in Major Industrialized Countries," Office of Competitive Assessment, U.S. Department of Commerce, October 1975.

"Booms and Slumps: The Impact on U.S. Trade," by Geoffrey H. Moore, *Morgan Guaranty Survey*, November 1975.

"Business Indicators: Growth and Classical Cycles," by Philip A. Klein, *Euromoney* (London, March 1976), pp. 42-45.

"Recent Work in International Economic Indicators: Problems and Prospects," by Philip A. Klein, *Industriekonjunkturen* (Swedish Federation of Industries, Spring 1976) pp. 115-128.

The international indicator data organized in a manner similar to that used in the monthly publication of the U.S. Department of Commerce, *Business Conditions Digest*, have been assembled in a prototype of a proposed current publication, *International Economic Indicators*, and made available to interested parties.

The basic findings of this research program are set forth in a draft volume tentatively entitled "Monitoring Business Cycles at Home and Abroad," which is being prepared for publication. Covering the five countries above, it is designed to be extended to other countries as data analysis permits, and will, among other things, provide an historical record of cyclical behavior that can be consulted as an aid to interpretation of current information on indicators in these countries.

We have also begun experimenting with a variety of possible uses to which international growth cycle chronologies and indicators for

these chronologies might be put. An obvious candidate for such experimentation involves international trade. We have previously reported that exports tend to conform to growth cycle phases in the country of destination. Leading indicator indexes are closely associated with growth cycles as well. In the five countries that we have so far examined (the United States, Canada, West Germany, the United Kingdom, and Japan) these indexes lead by four to six months on the average. These conclusions suggest that leading indexes for these countries' growth cycles could be used to forecast U.S. exports to these major trading partners (i.e., their imports). Similarly, the U.S. leading index could be used to forecast their exports to the U.S. (our imports). In this way changes in the trade balance with each country, or with all countries combined, might be forecast as well.

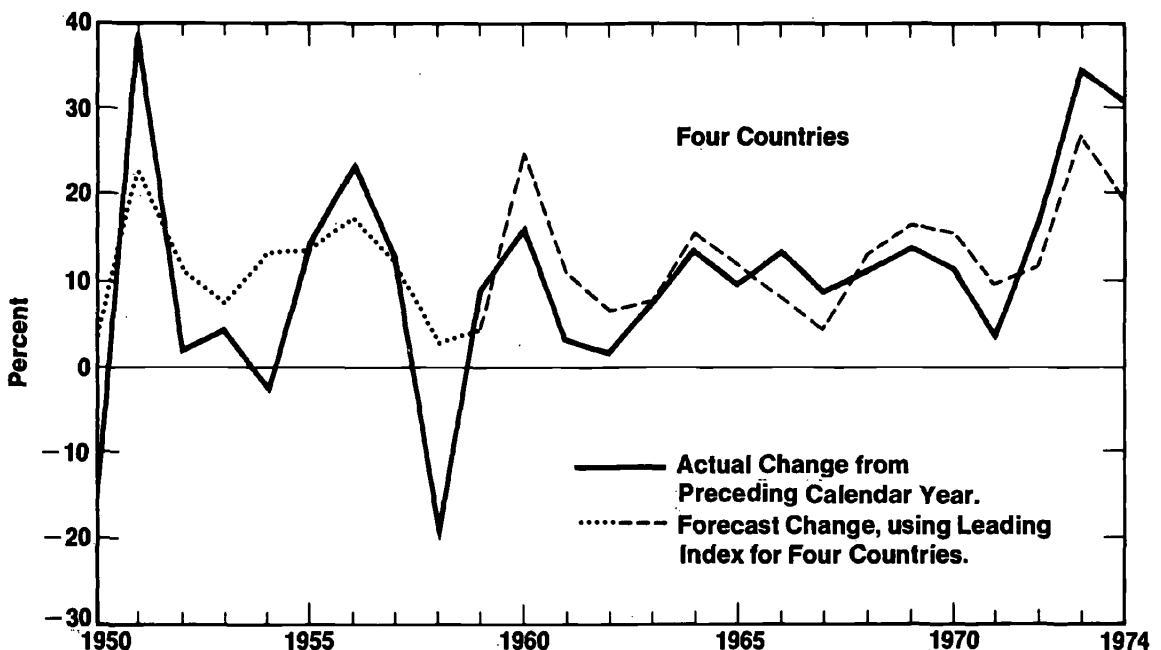
A method for forecasting changes in domestic economic activity by using a leading index was

developed some years ago at the NBER. One variant of this method is to use the percent change in a leading index from (a) its average during the fiscal year ending June to (b) December of the current calendar year as the independent variable, with the percent change from the current calendar year to the next calendar year in the variable to be forecast as the dependent variable. This method assumes a uniform six-month lead in the leading index over the variable being forecast. As an initial test we aggregated the data on the value of U.S. exports to Canada, the U.K., West Germany and Japan and forecast the year-to-year changes in these exports with a composite leading index of the approximately 12 leading indicators for each of the four countries (or 48 in all), using a simple linear regression fitted to the data for 1959–1973.

About 55 percent of the variance of the change in exports is accounted for by the change in the leading index (see Figure II-1).

Figure II-1

U.S. Exports to Four Countries (Canada, United Kingdom, West Germany, Japan),
Percent Change from Preceding Year



Note: Forecasts are based on regression fitted to 1959–1974. The forecasts for 1950–1958 (dotted line) use the 1959–1974 regression equation in order to test its forecasting value on a different period.

The average error in the forecast was 5.2 percentage points compared to an actual percentage change in exports during the test period of 12.5 percent. The difference is the gain over a naive "no change" forecast in using the leading index. Clearly the forecast changes do suggest in general the subsequent change in exports. As a further test we used the same regression equation to forecast exports in an earlier period, 1950-1958, and the results of this experiment are also shown in the chart. The mean forecast error, 10.6, was nearly twice as large as for the later period. The difference is due largely to the far greater stability of exports in the later period than in the earlier period, a change which the leading index did not share.

We have also used this technique to forecast U.S. imports from the four countries, using the leading index for the U.S. and import data for the combined four countries. The results are similar to those for exports. We have also combined the import and export forecasts to forecast the U.S. trade balance, with similar results. In all these tests about half the total variance of the year-to-year changes in exports, imports, and trade balances is accounted for by the prior change in the leading indexes. A paper by Moore on "Forecasting Foreign Trade Flows with Leading Indicators" was presented at a Conference of the International Federation of Associations of Business Economists, Cambridge, England, April 3, 1976, and is to appear in *The Business Economist*, Journal of the Society of Business Economists (Oxford, Summer 1976).

In the coming months we intend to extend these investigations in a variety of ways, as well as to implement our plans to develop an up-to-date computer bank at the NBER for indicators from a number of countries. Such a data bank, similar to the NBER's data bank for U.S. time series, which is now used by more than 100 companies and other organizations, would benefit not only our own research but also the contributors of data and the many groups that we hope will help to finance the project (business concerns, international agencies, government agencies, foundations, etc.). By utilizing a system of computer terminals in various cities and countries to collect and disseminate the data and analytical results, the distribution of this in-

formation could be expedited. In this way the collection of the data essential to ongoing research in this field can, we hope, finance itself.

During the past year the program has been supported by funds from the U.S. Department of Commerce and the American Enterprise Institute, as well as by general funds of the NBER.

Geoffrey H. Moore

Philip A. Klein

Cyclical Indicators

New composite indexes of leading, roughly coincident, and lagging indicators were first introduced in 1975 by the Bureau of Economic Analysis (BEA), U.S. Department of Commerce, in two articles by Zarnowitz and Boschan which appeared in the BEA monthly report, *Business Conditions Digest (BCD)*.¹ Since then the new indexes and their components have been published currently in *BCD*, and a comprehensive review of a large number of indicators has been completed. This resulted, among other things, in a set of proposals concerning the revision of the contents and format of *BCD*. Major parts of this project were carried out by the staff members of the National Bureau; and substantial contributions were made by the Statistical Indicators Division of BEA.

The review of the NBER Reference Chronology for the period since 1947, on which we reported last year, has been extended to cover the latest developments, namely the 1975 recovery, and to take account of the most recent revisions of the national income accounts, industrial production, and other data. In this work, a set of twelve indicators in real terms and seven indicators in current dollars was used. The indicators consist of the principal available measures of aggregate income and expenditures, value of output and sales, volume of production, employment, and unemployment.

A close analysis of these data confirmed all the dates of business cycle turns previously established, including that of the latest peak in November 1973 which on balance is well supported by the evidence, despite the unusually

1. Victor Zarnowitz and Charlotte Boschan, "Cyclical Indicators: An Evaluation and New Leading Indexes," *BCD* (May 1975) and "New Composite Indexes of Coincident and Lagging Indicators," *BCD* (November 1975).

few, tardy, and mild declines in the current-dollar series as well as late downturns in total employment and industrial production.

The date of the latest trough is placed in March 1975. Given the data now available, March is definitely the best choice, being the lowest month in the composite and diffusion indexes for the principal coincident series in both real and nominal terms, although several important indicators of employment, unemployment, and production reached their troughs somewhat later, in April-June 1975.

The chronology of U.S. growth cycles in the post-World War II period has also been reviewed and updated using the same set of time series in form of deviations from their long-term trends. The computed trends are based on seventy-five-month moving averages, as in the work by Ilse Mintz² who initiated this approach. However, modifications were designed to insure that the rates of change in the estimated trends are reasonably stable and do not contain residual cyclical elements. This analysis largely corroborates the results obtained by Mintz, though some of her reference dates are revised. According to the new reference chronology, the latest low-growth phase of the U.S. growth cycle may be viewed as having started in March 1973 and ended in April 1975.

Table II-4 summarizes the scores and the recent and historical record of cyclical timing for the new indexes of leading (L), coincident (C), and lagging (Lg) indexes and their components. Users of indicators will find it of interest to compare the performance of these series in 1973-1975 with their performance in the sample period 1947-1970. The conclusions from such a comparison are generally favorable. The L, C, and Lg indexes continued to lead, coincide, and lag, respectively, and with very few exceptions so did the individual component series in the three corresponding groups. Each cycle has some unique features, however, and this one does, too. Notably, the lagging index had a much longer than average lag in the 1973-1974 recession period, and its lag in the present recovery may turn out to be even longer. (The

trough in Lg has not yet been firmly identified in the data extending through July 1976; a tentative date is now January 1976, which would be a lag of 10 months.) This reflects largely the unusual sluggishness in the current recovery of business investment and related series (inventories, commercial and industrial loans, and prime rate).

Victor Zarnowitz
Charlotte Boschan

Model Comparison Project

During the period since the last progress report, work on this project has proceeded in two directions. Phoebus J. Dhrymes continued his examination of the problems involved in the evaluation of the performance of econometric models and Victor Zarnowitz has continued his examination of forecasts from other sources.

Dhrymes has promoted work on the problem of obtaining the asymptotic distribution of full information maximum likelihood estimators for models that are nonlinear in variables only, as is the case with most of the models now in use. Michio Morishima, during his stay at the Bureau, has continued this work and has produced the paper "On the Full Information Estimation of the Simultaneous Equations Model which is Nonlinear in the Variables Only."

In addition, work continued on the compilation and preparation of econometric model records. Ray Fair has supplied records of his coefficients, lagged endogenous and exogenous variables used in his forecasts, as well as his latest data banks. Using this information, we have constructed a program that is capable of reproducing all of his forecasts to within second decimal digit accuracy. We are thus certain that, in the case of the Fair model, we have attained reproducibility. The necessity for this will be discussed briefly below.

From Albert Hirsch we have received records of the BEA model. Unfortunately, the records for that model were transcribed in UNIVAC language and it was necessary to translate them to IBM language. This was a very lengthy and complicated task; in addition, the program used for generating forecasts was not sufficiently flexible for the purposes of the simulation experiments to be undertaken later. Thus, another

2. "Dating United States Growth Cycles," *Explorations in Economic Research* (Summer 1974), pp. 1-113.

TABLE II-4

Cyclical Timing and Scores, Indexes of Leading, Coincident and Lagging Indicators and Their Components, 1947-1975

| | Timing at 1973-1975 Business Cycle Turns in Months ² | | Median Timing at Business Cycle Turns, 1947-1970 in Months | | | Total Score ³ (6) |
|---|---|-----------------------|--|----------------|------------------|------------------------------------|
| | Peak 11/73 (1) | Trough 3/75 (2) | Peaks (3) | Troughs (4) | All Turns (5) | |
| Composite Indexes | | | | | | |
| Leading | -5 | -1 | -11 | -2 | -5 | 82 |
| Coinciding | 0 | 0 | -1 | 0 | 0 | 87 |
| Lagging | +13 | +10 | +3 | +5 | +4 | 86 |
| Components of Leading Index | | | | | | |
| 1 Average workweek, mfg. | -9 | -1 | -12 | -2 | -5 | 73 |
| 3 Layoff rate, mfg. (inverted) | -9 | -2 | -11 | -1 | -6½ | 76 |
| X213 New orders, consumer goods and materials, 1967 dollars | -6 | 0 | -6 | -1 | -4½ | 74 |
| 32 Vendor performance ⁴ | -6 | -1 | -6 | -5 | -6 | 69 |
| 12 Net bus. formation | -8 | -1 | -11 | -2 | -3 | 73 |
| 10D Contracts and orders, plant and equipment, 1967 dollars | 0 | +9 | -9 | -2 | -5½ | 72 |
| 29 New bldg. permits, priv. hous. units | -11 | -2 | -13 | -8 | -9½ | 76 |
| X170D Change in stocks on hand and on order, 1967 dollars ⁵ | -4 | +1 | -5 | -4 | -4½ | 71 |
| 19 Stock price index, 500 common stocks | -10 | -3 | -9 | -4 | -5½ | 80 |
| X201 Percent change, price index for crude materials ⁵ | +5 | -1 | -15 | -5 | -5½ | 72 |
| X108 Money supply, 1967 dollars (M1/CPI) | -10 | +10 | -10 | -8 | -9 | 79 |
| X136 Percent change, liquid assets ⁵ | -10 | -2 | -6½ | -6 | -6 | 75 |
| Components of Coincident Index | | | | | | |
| 41 No. of employees on nonaggregated payrolls | +10 | +3 | -2 | 0 | 0 | 88 |
| 47 Index of industrial production | +7 | 0 | -3 | 0 | -1½ | 86 |
| X234 Personal income, less transfers, deflated by PCE | 0 | -1 | 0 | -1 | -1½ | 78 |
| 56D Mfg. and trade sales deflated | 0 | 0 | -3 | 0 | -1½ | 78 |
| Components of Lagging Index | | | | | | |
| X1 Average duration of unemployment | +1 | +9 | +1 | +8 | +3½ | 86 |
| 62 Labor cost per unit of output, mfg. | +16 | +6 | +8½ | +11 | +10 | 73 |
| 71D Mfg. and trade inventories, 1967 dollars | +14 | +9 | +2½ | +3 | +3 | 80 |
| 72 Commercial and industrial loans outstanding, weekly reporting large commercial banks | +13 | nt | +1½ | +5 | +3½ | 83 |
| 109 Average prime rate charged by banks | +10 | +14 | +3½ | +14 | +4 | 87 |
| X251 Ratio, consumer installment debt to personal income | +3 | +7 | +6½ | +7 | +7 | 74 |

Note: nt = No turn has been determined as of July 1976.

1. Numbers are those used in *Business Conditions Digest*. X refers to temporary numbers of new series. D denotes deflated series.

2. Leads are indicated by -, lags by +.

3. Total scores are weighted averages of scores for economic significance, statistical adequacy, cyclical conformity, cyclical timing at both peaks and troughs, smoothness and currency. They are on a scale of 0 to 100. For a description of the scoring system see Zarnowitz and Boschan "Cyclical Indicators, an Evaluation and New Leading Indexes" *Business Conditions Digest* (May 1975) pp. 2-4.

4. Percent of companies reporting slower deliveries.

5. Series smoothed with weighted 4-month moving average.

major effort had to be undertaken in order to render the program flexible and suitable to our own requirements.

Lawrence Klein provided the records containing the WEFA forecasts. Although the records are easy to handle and well documented, preliminary checking reveals that they do not duplicate the forecasts to which they correspond. The nature of the difficulty has yet to be determined.

In general, model builders have cooperated with us in providing their records, and we are indeed quite thankful for their valuable assistance. We have, on the other hand, severely underestimated the difficulties involved in reproducing their results from their own records. This indicates to us that serious thought ought to be given by those engaged in empirical research regarding the extent of necessary record keeping.

In general, we have records for the three models noted above, over the period 1970–1974. In the case of the Wharton model it is not possible to get complete records prior to the third quarter 1972 forecast. What we shall be compelled to do in this case, as well as in the case of the Fair model, is to forego some part of the disaggregation of the forecast error, for lack of the requisite information.

The method of operation in decomposing the forecast error, as outlined in our proposal and previous progress reports, is to design a number of simulation experiments which would allow us to isolate the errors due to ignorance of true parameters, the presence of structural errors (these are the irreducible components of error), the use of incorrect exogenous variables, data revisions, constant adjustments, and an unexplained residual. To this end, it is important that we have at our disposal exactly the information available to the model operator at the time of forecast. This is not the case for the Fair model, and for the Wharton model for the period 1970 Q1–1972 Q2. In this case we shall simply have to be satisfied with a coarser form of decomposition.

In the context just explained the need for reproducibility of the model operators' forecasts becomes quite evident. Without reproducibility we cannot be certain that we operate with

the same information set available to them at the time of the forecasts. Since this is in doubt we cannot be certain that our decomposition corresponds to the categories enumerated above; consequently, it would not be clear what inferences are to be drawn from the residual component of the mean square error of forecast. Thus, apart from being an important characteristic of the scientific method, reproducibility is, in our case, an essential ingredient of the procedure.

Forecasts obtained from the quarterly ASA/NBER Survey of the Economic Outlook provide rich material with which the predictions of econometric model builders can be compared. This part of our project, directed by Victor Zarnowitz, will benefit from his collaboration with Charlotte Boschan on the analysis of each of the ASA/NBER surveys conducted regularly since 1968, and from the recent work on the selected average forecasts from the same source by Vincent Su and Josephine Su (see their paper in *Explorations in Economic Research* (Fall 1975) pp. 588–618).

Generally it is difficult to compare different forecasts because of disparities in dates of issue, vintages of time-series data used and choice of exogenous variables and methodology. To make the comparisons meaningful and their interpretation instructive, it is necessary to have considerable amounts of specific information about the forecasts that is often lacking. Fortunately, we are relatively well positioned for such studies, since our projects supply much detailed knowledge of the required type on the econometric model covered and the individual replies to the successive ASA/NBER survey questionnaires provide much information on the other predictions. Thus, we have data on the methods preferred by the respondents that permit us, for example, to separate those who subscribe to econometric forecast services or use their own model from those who rely principally on more informal approaches. We have the survey participants' specific assumptions regarding future economic policies and other exogenous factors. One important variable usually treated as exogenous, national defense expenditures, is regularly predicted in the surveys. To a large extent, we can trace the effects of

the data revisions on the successive predictions from each individual source.

Phoebus J. Dhrymes
Victor Zarnowitz

Measurement of Business Inventories

The problem of measuring inventories and their change in an inflationary period is more interesting and challenging than we had originally thought. Over the past several months we have gained new insights into the quality of currently reported inventory statistics and have begun to devise a methodology which could be applied to remedy some of the deficiencies that have appeared.

Before this project was started, it was known that shifts in methods of inventory valuation by business over the past few years were making it more difficult than formerly to interpret movements in book values of inventories. It was believed, moreover, that interpretation of book value changes would be relatively straightforward provided one had information about valuation methods utilized and about shifts and transitions to new methods. This has not turned out to be so. On the basis of a limited amount of field investigation we have found that valuation methods used for year-end financial reporting are not necessarily applied for interim (less than a year) reporting. It was discovered that some firms (including large corporations) that have described themselves as "LIFO companies" in financial reporting and to the Census Bureau, either never report LIFO inventories to the Census Bureau or report a LIFO figure only at year-end. Furthermore, many firms that make LIFO calculations during the year employ crude methods for monthly or quarterly calculations. In response to our identification of these problems, the Census Bureau is conducting a retrospective survey of LIFO companies to check monthly figures reported during 1975. In addition, work is proceeding on new report forms which are directed specifically to current monthly reporting of LIFO firms. A new form also is being devised for firms who report standard costs in order to insure the comparability of figures in adjacent months.

The reporting of retail inventories has always been difficult because of low response rates.

Experimental work designed to test alternative approaches to the retail problem is underway. At the present time retail inventories are collected from a relatively small number of firms and also through a survey that is separate from the regular large monthly survey of retail sales. One experiment will be concerned with whether the addition of a question asking for inventories in the sales survey will significantly alter the response rate for sales. Another experiment will attempt to estimate monthly inventory change by subtracting from monthly purchases, monthly sales which have been reduced to cost by the firm's gross margin of the year before.

Work has also begun to test the most appropriate method of inventory reporting by large companies with a high degree of vertical or horizontal integration or diversification. On the one hand it is desirable from the point of view of the national accounts and financial analysis that reported profits, which ordinarily refer to the consolidated company, be consistent with reported inventories. For the analysis of production, highly disaggregated figures are needed, but problems arise as soon as one starts to disaggregate a consolidated company figure. Establishment inventory figures (plants, stores, etc.) tend to be less than comprehensive and frequently employ valuation methods different from those used at the company level.

We have also made a start in measuring inventory float as it is related to exports and imports. Furthermore, we have started to examine the problem of "full cost absorption," that examines the treatment of overhead costs and the costing of inventories. A recent IRS regulation has caused many thousands of firms to change their inventory accounting for this purpose.

Two reports of this work were presented at meetings of the Subcommittee on Economic Statistics of the Economic Policy Board (EPB), chaired by Burton Malkiel, member of the Council of Economic Advisers. An interim progress statement was issued and is available on request. This research is supported by the Bureau of the Census, U.S. Department of Commerce.

Murray Foss
Gary Fromm
Irving Rottenberg

Determinants of Investment

The manuscript, "Factors in Business Investment," mentioned in the 1975 Annual Report, has been completed and revised on the basis

of comments by staff readers. It is now being edited prior to submission to the Board of Directors for approval for publication.

Robert Eisner

2. URBAN, REGIONAL, AND ENVIRONMENTAL STUDIES

Urban Studies

Introduction

In the past year, the NBER Urban and Regional Studies Group has been engaged almost exclusively in an effort to complete the final programming and calibration of an improved version of the NBER Urban Simulation Model. This increased emphasis on model development resulted in part from the completion of the NBER series of econometric studies of urban housing markets culminating with the publication of John Kain and John Quigley's study of the St. Louis housing market, *Housing Markets and Racial Discrimination: A Microeconomic Analysis*.¹ In addition, John Quigley completed his study of the Pittsburgh housing market and published a paper, "Housing Demand in the Short Run: An Analysis of Polytomous Choice," in the Bureau's journal, *Explorations in Economic Research*.²

The major part of our research during the past year has been funded by the Department of Housing and Urban Development. In November 1972 a two-year contract was received from HUD to further develop the NBER Urban Simulation Model and to use it to analyze housing abandonment. In June 1974 HUD provided additional funding and a one-year extension of the contract so that model development and support research activities could be redirected toward an evaluation of the impact of housing allowances on urban housing markets.

This was a substantial challenge, yet we feel we have made significant progress in developing the NBER Urban Simulation Model into a usable tool for policy analysis. At the same time,

we have attempted to demonstrate the value of our systematic approach to urban housing analysis with the preparation of several working papers evaluating the housing allowance program. These interim analyses were originally presented to HUD in the fall of 1974. In the past year, the results of these analyses were given wide circulation in the form of several working papers. Gregory K. Ingram and Yitzhak Oron presented results from an improved stand alone model of housing supply to the NBER Conference on Income and Wealth,³ while John Kain and William C. Apgar, Jr. presented a paper on the analysis of demand implications of the housing allowance program to the January 1975 meeting of the American Academy for the Advancement of Science.⁴

The results of these analyses anticipated the results currently emerging from simulations of the impact of the housing allowance program being conducted with the NBER Urban Simulation Model. The current HUD contract will be completed this spring with a series of baseline simulations for the 1960–1970 period for Chicago and Pittsburgh and a number of housing allowance program simulations for the same two cities.

With our current contract with HUD drawing to a close, several major tasks remain. We are now engaged in the extensive task of documenting the current version of the model, the econometric analyses used to calibrate the model, and the findings of the initial baseline policy

1. John F. Kain and John M. Quigley, *Housing Markets and Racial Discrimination: A Microeconomic Analysis*, (New York: National Bureau of Economic Research, 1975).

2. John M. Quigley, "Housing Demand in the Short Run: An Analysis of Polytomous Choice," *Explorations in Economic Research* (Vol. 2, Spring 1976) pp. 76–102.

3. Gregory K. Ingram and Yitzhak Oron, "The Behavior of Housing Producers," a paper presented at the National Bureau of Economic Research Conference on Income and Wealth, Session on the Economics of Residential Location and Urban Housing Markets, Cambridge, Massachusetts, May 1975.

4. John F. Kain and William C. Apgar, Jr., "Computer Simulation of Urban Housing Markets and the Evaluation of Housing Allowance Programs," a paper presented at the annual meetings of the American Association for the Advancement of Science, New York City, N.Y., January 1975.

simulations. The final report to HUD will consist of two volumes: Volume I will present a detailed description of the model, its calibration, and the results of the baseline and policy simulations. Volume II will present a detailed discussion of the econometric studies of housing supply used to calibrate the newly designed supply sector of the new Bureau model.

Our growing experience with the NBER Urban Simulation Model has increased our confidence about the value of computer simulation models for theory building and policy analysis. We hope to continue to improve and adapt the model to a variety of policy questions and as a result we are actively seeking additional funding to support further research. To assist us in charting the best course for our future research, we held a meeting of the NBER Urban Studies Advisory Committee in Cambridge in March 1976. This meeting yielded both valuable criticism of our current efforts and guidance about directions for future research.

John F. Kain

The NBER Urban Simulation Model and Evaluation of the Housing Allowance Program

Our current HUD contract obligates us to calibrate an improved version of the NBER Urban Simulation Model to Pittsburgh and Chicago and to use these models to simulate the housing market effects of allowance programs. In the current version of the NBER Urban Simulation Model we employ a fundamentally different method of data storage and processing than in earlier versions of the model. Specifically, the new version stores household and housing unit data as individual sample observations rather than as the elements of large matrices of characteristics. This fundamental 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.¹

1. John F. Kain et al., "First Interim Report on Contract to Improve the NBER Urban Simulation Model," Report to HUD under contract number H-1843, June 1973 (processed) and John F. Kain, editor, "Progress Report on the Development of the NBER Urban Simulation Model and Interim Analyses of Housing Allowance Programs," Report to HUD under contract H-1843 (amended), December 1974 (processed).

The approach to data storage and processing that we have incorporated into the current version of the NBER model has many advantages over that employed in earlier versions 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. A complete discussion of the required changes will be presented in Volume I of our forthcoming final report. The changes include an extensive reworking in the supply sector of the model. The new supply sector draws heavily on theoretical and econometric work of Gregory K. Ingram, Yitzhak Oron, Herman Leonard, and Robert Schafer that is described in the next section of this report.

At the same time we have completely redesigned and reprogrammed 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 including job choice and retirement submodel and a tenure choice submodel.

Our initial simulations with the revised NBER model have proven quite satisfactory. While there remain many possible refinements in model design and calibration, the current simulations appear to be more than adequate to demonstrate both the feasibility and the value of the simulation approach to urban analysis.

In the next few months we plan to conduct further simulations in an effort to both evaluate the performance of the model and to enrich our understanding of the likely market impacts of

a housing allowance program.

John F. Kain
William C. Appgar, Jr.
J. Royce Ginn

The Supply Side of the Housing Market

Earlier versions of the NBER Model represented the supply side of the housing market in a reduced-form manner that has become increasingly unsatisfactory as other portions of the model have improved. Therefore, we have made a major effort to design an improved representation of housing supply activity and to better ground it in empirical analysis.

In this representation, we assume that the owners of existing structures differ in their abilities to produce the several housing attributes demanded by housing consumers. As a result, some attributes, such as dwelling-unit quality, which are produced by using operating inputs and short-lived capital, are fairly elastic in supply. Other attributes, such as structure type, which are produced using long-lived capital, cannot be easily supplied in the short run and are thus inelastic in supply. And finally, housing attributes, such as neighborhood quality, can not be produced by housing suppliers and yet have major effects on demand and rents.

In the past year, we calibrated a simple stand alone model of supply of dwelling unit quality and used it to make conditional predictions about the magnitude of short-run price increases that would occur as a result of the introduction of a housing allowance program. This stand alone model of housing supply served as the prototype for the design of several of the new supply subroutines which have been included in the NBER Urban Simulation Model.¹

The stand alone model also proved to be a useful organizing device for an expanded program of econometric analysis of housing supply. Central to this effort is a continuing analysis of supply activities based on an NBER spon-

sored survey of landlord behavior. Interviews were conducted in three Pittsburgh and ten Chicago neighborhoods in the beginning of the summer of 1974. In the past year, editing and coding of the data was completed and preliminary analyses were initiated. These initial investigations indicate that landlords do not make many changes in their maintenance and operating policies; very few of the landlords interviewed admitted to a change in these policies during the last five years. The preliminary analysis also indicates that profitability and maintenance policies vary with the type of landlord. These differences appear to be related to differences in the 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 capitalization) 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 indicates that there is a considerable amount of variation in landlord behavior among neighborhoods, which is not susceptible to simple explanation. For example, one might expect capital expenditures to be less in the declining neighborhoods but some owners make capital expenditures that are as large or larger than those made by landlords in better neighborhoods.

We plan to extend and enrich these analyses of landlord behavior using both the NBER landlord survey and other available data. In doing so we hope to be able to provide improved specification and calibration of the supply activities of the NBER Urban Simulation Model. We currently plan to complete our initial investigation of these issues and to present both the analyses using the stand alone supply model and the findings of our econometric research in

1. For a more complete discussion see Gregory K. Ingram and Yitzhak Oran, "The Behavior of Housing Producers," a paper presented at the National Bureau of Economic Research, Conference on Income and Wealth Session on the Economics of Residential Location and Urban Housing Markets, Cambridge, Mass., May 1975.

Volume II of our final report to the Department of Housing and Urban Development.

Gregory K. Ingram

Yitzhak Oron

Herman B. Leonard

Robert Schafer

Mobility of Households' Residences and Workplaces

It has been suggested that a household's decisions to move the residence and workplace locations are interrelated. Some economists assume a specific causality, from workplace to residence ("workplace dominance"), while most sociologists reject workplace-related reasons. Households are hypothesized to be more likely to move when they have experienced some unforeseen change in their short-run equilibrium, conditional on the levels of some variables used as proxies for the social and psychological factors influencing the household.

I have completed a draft of a paper investigating the simultaneity of household mobility decisions. The study is based on data collected in 1965 by The Bay Area Transportation Study Commission on 3,187 households living in the San Francisco Bay Area. Several econometric problems are involved in the analysis of the data: dichotomous dependent variables, pooling cross-section and time-series data, and simultaneous estimation. The method chosen was the Zellner-Lee joint estimation technique for linear probability models using pooled data.

The results indicate that virtually all groups, with the possible exception of Negro female renters, make their residential and workplace mobility decisions independently. However, some groups, most notably Negro males, appear to be constrained in their location decisions.

The paper has undergone staff review and is currently being revised for publication.

Daniel Weinberg

Fiscal Zoning and the Property Tax Base

I have begun some work this year on the impact of suburban large-lot zoning on the urban housing market, focusing on land values as well as property tax base. As an initial step I examined the long-run impact of large-lot zoning in a two-jurisdiction general equilibrium spatial model

of an urban area. Unlike most spatial models, this model allows both the price of land (business and residential) and the wage rate to be endogenous. In addition, I include a suburban business area (and a central business district), thus allowing for an analysis of the impact of zoning on jobs as well as residential location. Whether or not I assume that the urban area is closed or open (to inhabitants of other urban areas), the extent to which a zoning policy is exclusionary is shown to depend crucially on the nature and distribution of jobs throughout the urban area. The results also suggest some of the difficulties involved with the interpretation of cross-section empirical studies of the impact of zoning on land prices. On one hand, a stringent zoning policy is likely to create an excess demand for housing and cause housing and land prices to increase, while on the other hand, the zoning policy forces housing to be produced inefficiently which (other things equal) causes land prices to fall. As a consequence, it is possible for a zoning policy which is constraining in terms of housing and job location to have no *net* impact on land prices.

Daniel L. Rubinfeld

Regional and Environmental Studies

Introduction

During the past year two major studies have been completed. In the first, the impact of federal water pollution control legislation on six major water-using industries was examined. This project, under the direction of Robert A. Leone and J. Royce Ginn, was supported by the National Commission on Water Quality. Reports to the Commission are now available from the National Technical Information Service. In the second, a review of federal economic development programs, the Economic Development Administration's role in promoting regional development since 1965 was emphasized. The work was supported by a grant from EDA. Robert A. Leone and E. K. Smith were the project directors.

In June the preliminary results of Eugene Seskin's work on air pollution and health were

presented at the Air Pollution Control Association annual meeting. This study involves analyzing the incidence of health effects from air pollution episodes in the Washington, D.C. metropolitan area. The work is supported by the Environmental Protection Agency and the U.S. Department of Transportation. Henry Peskin and Leonard Gianessi completed their analysis of revising EPA estimates of meeting the costs of 1977 requirements of Federal Water Pollution Control Act Amendments of 1972, a summary of which is given in this section. This work was supported by the Environmental Protection Agency.

Research continues on the Income Determination Input-Output Model (IDIOM) under the direction of Stephen Dresch. The model is designed to simulate the differential effects of basic changes in public policy instruments such as tax, transfer, and expenditure policies. Adjustments by region, industry, and occupation can be reflected. During the past few months numerous interactive programming improvements have been made to increase the accessibility to users for model applications, and work continues on a second generation of the model. During the past year this project has been supported by the Economic Development Administration, U.S. Department of Commerce; the Office of Competitive Assessment and Business Policy, U.S. Department of Commerce; the Office of Minerals Policy, U.S. Department of the Interior; and by the National Bureau.

Daniel L. Rubinfeld, during his year as an NBER post-doctoral fellow, has completed a paper on voting in a local school election that is to be published in the *Review of Economics and Statistics*. He is continuing his work on an analysis of the willingness to pay for air quality improvements, using the housing market as a method of valuing the benefits of clean air and he has also started to work on a study of the impact of large-lot zoning on urban housing market values.

E. K. Smith

Federal Economic Development Programs

The study of the Economic Development Administration has been completed and submitted to

EDA. In this study, supported by the EDA, the focus was on the history and theory of federal involvement in regional development, the institutional record of EDA, including its legislative history and its changing mandate, and a statistical evaluation of its allocation of funds and their economic impact. Also included was a chapter placing EDA within the context of other federal programs which impinge on regional welfare.

Federal involvement in area development is long standing, beginning with the Gallatin and Clay plans for internal improvements in the early nineteenth century. Before the idea of depressed or lagging areas received attention in the United States, the federal government was developing and applying many of the tools upon which area development programs would later rely. But there has always been argument as to the extent of the federal role and conflicts within the body politic over geographical selectivity of programs. Pressures to disperse aid widely effected the evolution of EDA programs. In the period 1971–1973 the eligibility list for EDA programs was greatly expanded; by 1973 more than half of all rural counties were designated. A shift from a focus on regional distressed areas to a countercyclical focus was evident. At the same time pressures increased to eliminate direct federal aid except in the form of revenue sharing. This brought a new form to the ever-present dispute over federal involvement in local economic problems. However, when national unemployment rises, countercyclical programs tend to support increases in depressed area funds, while prosperity causes a waning of interest, even though in times of prosperity the likelihood of successful application of area development funds increases. The conflict between short-cyclical policies and long-run development objectives is evident. EDA has been able to respond to changing congressional mandates and despite predictions of its imminent demise, the agency has continued to receive the support of the Congress.

Analyses of variance and regression techniques were used in making intercounty comparisons of EDA spending impacts over the period 1967–1972. Five samples of rural counties were used to test structural equations. Significant socioeconomic differences exist among

the subsets, e.g., poor counties differ appreciably from slow growing counties. Cross-sectional models of 1970 labor market conditions and models of labor market changes for 1967–1972 were used to relate incomes, wages, and labor force participation to employment opportunities and other variables. Some interesting differences emerged. For example, the share of manufacturing variable is not significant in explaining income in the Southern and Appalachian samples, but is significant in the poor county sample. There is a positive correlation between share of the work force in agriculture and the labor force participation rate, but the equations are not useful in identifying “under-employment.” The negative correlation between in-migration and the number of people in urban areas is somewhat surprising. The income variable was not significant in explaining migration rates for southern counties. In the Appalachian sample, migration was positively related to the share of employment in farming. The share of employment devoted to manufacturing had important effects, increasing the nonfarm wage scale generally, and raising average manufacturing wages in the total sample (all rural counties) as well as the ratio of manufacturing wages to nonfarm wages. In the Southern sample the share of manufacturing employment in nonfarm employment is insignificant in the manufacturing wage equation, implying that the labor supply curve for manufacturing workers is elastic in poor, depressed regions. This has implications for the training of workers in these areas and appears to contradict the hypothesis of a shortage of trained workers.

In analyzing labor market changes, while the degree of urbanization was positively correlated, the *t*-ratio was not significant. For the Southern sample, the urbanization variable was negatively related to changes in both nonfarm and manufacturing earnings. This is consistent with the shift in manufacturing location toward more rural areas of the South. Equations for average wage levels revealed the expected positive relationships with employment growth, urbanization, and increase in share in manufacturing employment, but education and share of employment exhibited negative signs. The labor supply may be more elastic with shifts from the farm to non-

farm sector indicating wage increases. The least urbanized areas of the South are enjoying the most rapid growth in earnings and unlike the total rural sample, wage levels are being bid upward.

The effects of EDA expenditures on nonfarm and manufacturing earnings and employment for all rural counties do not exhibit high degrees of statistical significance, but the *t*-statistics exceed 1.0 and the coefficient has a positive sign, indicating a positive EDA impact. In a lagged model, where EDA effort is measured by per capita EDA expenditures 1965–1970, hypothesized to alter performance in 1970–1973, poor quality of fits were shown. Though the lagged dependent variable (1968–1970) is statistically significant in explaining 1970–1972 performance, the relationship accounted for a very low fraction of the variance. Growth in the nonfarm sector is apparently slower in the more “urbanized” counties of the total rural sample. In the manufacturing sector, growth in both earnings and employment in 1970–1972 was faster in counties with a large farm sector and a smaller share of nonfarm employment devoted to manufacturing. Job growth was most rapid in more rural, less industrialized counties. The coefficients for the EDA expenditure variable has the appropriate positive sign in all equations tested, thus indicating a positive regional growth impact.

For subsamples, only the Southern sample revealed a statistically significant EDA expenditure variable. The results for the South are the most convincing statistical evidence we found that EDA programs had a statistically significant impact on a county’s welfare. The evidence also indicates that EDA expenditures create a bigger increase in nonfarm and manufacturing employment than in the corresponding earnings functions, with the implication that average wage levels must have been reduced by EDA expenditures. This might indicate that increases in labor demand caused by EDA expenditure lead to still larger shifts in labor supply curves and this appears more evident in the South than in the sample for the entire country. It can also mean that EDA expenditures were properly targeted, i.e., the sectors paying below average wages are more likely to be attracted to depressed rural

regions and were, in fact, encouraged to do so. Employment and total income will still rise. EDA programs did have a significant nonzero impact, for in the absence of any EDA programs, our analysis shows that incomes would have decreased in the designated counties.

A series of appendixes, also submitted to EDA, give a detailed description of data sources and provide extensive backup for summary statistical tables in the text.

The material has been extensively edited and after review by the sponsoring agency, plans for its dissemination by EDA will be made. Review for possible National Bureau publication will be undertaken when EDA plans are made final.

Robert Leone
E. K. Smith

Modeling the Differential Incidence of Federal Tax, Transfer, and Expenditure Policy (IDIOM)

This study has been devoted to the further development and elaboration of capabilities for the assessment of the differential consequences of alternative federal tax, transfer, and expenditure policies. At the present time this effort has two major foci. First, the existing policy evaluation model, IDIOM: (*Income Determination Input-Output Model*), has been modified and updated to enhance its applicability to the explication of contemporary policy options. Second, the design and implementation of more fully articulated, second-generation models have been undertaken. The first of these will involve the endogenous incorporation of investment and international trade flows, while the second will emphasize the household sector (income distribution, interregional migration, etc.).

In the first area, the input-output model incorporated in IDIOM has been converted from a total to a domestic base by utilizing the Bureau of Economic Analysis interim 1970 transactions table. Unlike the original model, in which import composition by sector was assumed to remain constant, the revised model permits stipulations of changes in import supplies. While each variant of the model is useful for particular purposes, the domestic base version is especially valuable in the assessment of the effects of disruptions

in world trade patterns, e.g., the 1973 petroleum embargo.

In addition to the development of a second variant, data inputs required by both versions of the model, such as exogenous final demand vectors, have been updated whenever possible to represent the U.S. economy in 1973. Similarly, all values have been converted from 1970 to 1973 prices. Thus, the models now incorporate many important economic changes that have occurred since 1970.

Finally, substantial effort has been devoted to improvement of the interactive programming features of the model and to thorough documentation of procedures required for its application to alternative policy scenarios. As a result, accessibility of the model to actual and potential users has been greatly increased. Several groups, governmental and nongovernmental, are now actively involved in model applications, utilizing the NBER-related computing facilities at Cornell University.

As noted, the second major focus of our efforts has been on the development of more fully articulated second generation models. The initial undertaking in this area has involved the design, by An-loh Lin and Wu-lang Lee, of a modified U.S. variant of the model developed by Saito for the Japanese economy. This model endogenously incorporates primary and intermediate input substitutions, investment and international trade flows, demand responses to changes in relative prices, and a monetary sector. An alternative focus, initiated by Stephen P. Dresch, involves the development of a household sector in which employment (by industry and occupation), labor and capital income, transfer payments, and private consumption expenditure are related to other demographic characteristics.

Both of these second generation efforts will be continued in the coming year. At a later stage it is anticipated that the two models will be reintegrated into a more comprehensive, general equilibrium portrayal of the U.S. economy.

Support for this research has been provided by a grant from the Office of Economic Research of the Economic Development Administration, U.S. Department of Commerce, in association with the Office of Competitive Assessment and Business Policy, U.S. Department of Commerce;

the Office of Minerals Policy, U.S. Department of the Interior; and augmented by internal NBER support. Professional staff for the study include Stephen P. Dresch, principal investigator, Wu-lang Lee, and Daniel A. Updegrove, who recently joined the project from Cornell University. Although An-loh Lin has taken a position with the research staff of the Federal Reserve Bank of New York, it is anticipated that he will continue to contribute to the project. Finally, John Kaler, formerly with the Economic Development Administration and now associated with the Office of Competitive Assessment and Business Policy, has undertaken the endogenous modeling of investment demand.

Stephen P. Dresch
E. K. Smith

Voting in Local School Elections

My recently completed paper "Voting in a Local School Election: A Micro Analysis," is to be published by the *Review of Economics and Statistics*. In the paper, I analyze the demand for local public education using individual household data obtained (with the assistance of George Peterson of the Urban Institute) through a survey of voters in two local school elections in Troy, Michigan. It is assumed in the voting model that individual voters determine their desired level of educational expenditures per pupil by maximizing a utility function subject to a budget constraint. They decide whether to vote for or against a given millage request by comparing their desired expenditure level with the actual and proposed levels. On the basis of some assumptions concerning the stochastic nature of the individual utility functions, the analysis suggests that the probability of a yes or no vote can be estimated using a binary logit form.

The empirical results are generally consistent with the notion that individual voters act in a manner that is coincident with their own self-interest, since the number of children in public school, income, and the price of schooling are three of the most important explanatory variables in the model. By estimating the model using alternative definitions of income and price I was able to reach some conclusions concerning the bias in estimates of income and price

elasticity that result from the failure to account for the deductibility of local property taxes and the inclusion of imputed rental income as income. In addition, my estimates of the relative magnitude of the income and price elasticities provide some information about specification biases associated with aggregated expenditure studies. Finally, I compared the outcomes of the two elections to test whether the newly introduced Michigan circuit-breaker law (property tax relief) could help to explain passage in the second election, when passage in the first election failed. The results suggested that the circuit-breaker was not an important cause of the election passage, but that when voters become more aware of the import of the circuit-breaker, the likelihood that school millage elections pass may increase substantially.

I hope to continue my research in the school voting area by concentrating on a generalization of the voting model which encompasses the voter turnout decision, as well as the yes-no choice.

Daniel L. Rubinfeld

Short-Run Costs of Water Pollution Abatement

The purpose of this project is to analyze and revise estimates made by the Environmental Protection Agency of the costs to meet the 1977 requirements of the Federal Water Pollution Control Act Amendments of 1972. A final report was delivered in EPA in December 1975.

Approximately 55 industry estimates were analyzed; the following conclusions can be drawn. The incremental investment cost of the 1977 requirements for existing industrial sources is about \$17.5 billion with powerplants, pulp and paper, iron and steel, petroleum, machinery and mechanical products, and miscellaneous chemicals accounting for over half of this total. On the average, the absolute difference between the original EPA estimates and the revised NBER estimates is about 55 percent. However, most of the difference could be accounted for by revisions made in seven sectors: organic chemicals, petroleum, iron and steel, electroplating, dairies, inorganic chemicals, and phosphates.

The most significant reason for revisions was a difference in interpretation between EPA and

NBER on what constitutes the true incremental cost of the EPA policy. Often we felt that EPA overestimated these costs by including the cost of equipment that, while consistent with EPA requirements, was not engendered by these requirements, but rather by local laws or by conventional industry practice.

Other reasons for revisions were differences in assumed engineering cost estimates, adjustments to the legal coverage and interpretation of the requirements, and the use of more up-to-date information on the number of industrial establishments.

A summary of the NBER revised estimates is shown in Table II-5.

Leonard P. Gianessi
Henry M. Peskin

TABLE II-5

NBER Revised Estimates of the Incremental Costs of Meeting the 1977 Requirements of the Water Pollution Control Amendments of 1972 (millions of 1973 dollars)

| EPA Industry Category | Investment Costs | Annual Costs ¹ |
|-----------------------|------------------|---------------------------|
| Asbestos | 1.2 | 0.3 |
| Bauxite | 52.8 | 12.5 |
| Beet Sugar | 8.0 | 1.6 |
| Builders Paper | 8.1 | 2.0 |
| Cane Sugar | 18.0 | 7.5 |
| Cement | 29.0 | 8.2 |
| Dairies | 44.7 | 14.1 |
| Electroplating | 1572.1* | 860.0* |
| Feedlots | 886.2 | 177.3 |
| Ferroalloys | 13.1 | 5.8 |
| Fertilizers | 76.9 | 48.2 |
| Fruits and Vegetables | 22.3 | 5.0 |
| Glass | 1.9 | 0.7 |
| Grain | negative | negative |
| Insulation Fiberglass | 8.3 | 2.6 |
| Inorganic Chemicals | 540.9 | 151.3 |
| Iron and Steel | 916.7 | 227.6 |
| Leather | 66.0* | 15.5* |
| Meat Packing | 65.6 | 13.0 |
| Organic Chemicals | 1997.2* | 499.2* |
| Petroleum Refining | 483.6 | 113.6 |
| Phosphates | 50.1 | 17.4 |
| Plastics | 177.4* | 36.1* |
| Powerplants | 1019.0 | 353.0 |
| Primary Aluminum | 23.9 | 8.6 |
| Pulp and Paper | 1597.0 | 341.0 |
| Rubber | 66.4 | 15.0 |
| Seafoods | 30.5 | 6.7 |
| Secondary Aluminum | 1.4 | 0.5 |
| Soaps and Detergents | 39.3* | 15.0* |
| Textiles | 104.7* | 24.2* |
| Timber | 64.7 | 33.1 |

| | | |
|-----------------------------------|---------|---------|
| Meat Processing | 2.1 | 0.7 |
| Nonferrous Metals ² | 5.8 | 2.8 |
| Poultry | 17.6 | 5.2 |
| Renderers | 1.3 | 0.5 |
| Coal Mining | 14.7 | 7.6 |
| Concrete Products | 52.7 | 23.2 |
| Fish Hatcheries | 13.9 | 2.7 |
| Furniture | 3.9 | 8.3 |
| Iron Foundries | 245.6* | 53.8* |
| Laundries | 262.4* | 65.9* |
| Machinery ³ | 4265.6* | 1577.4* |
| Mineral Mining | 23.5 | 9.4 |
| Miscellaneous Chemicals | 973.4* | 195.6* |
| Miscellaneous Foods and Beverages | 198.5 | 38.8 |
| Ore Mining | 64.6 | 23.3 |
| Paint and Ink | 0.0 | 0.0 |
| Paving and Roofing | 3.8 | 5.2 |
| Oil and Gas Extraction | 186.7 | 49.3 |
| Pottery and Clay | 17.7* | 6.1* |
| Printing | 14.3 | 2.9 |
| Steam Supply ⁴ | 101.5 | 44.7 |
| Transportation | 176.1* | 54.8* |
| Water Supply | 862.5 | 146.8 |
| Total | 17459.2 | 5341.6 |

Note: The 1977 requirements call for the installation of "Best Practicable Technology" (BPT) by plants discharging waste water directly to waterways and "pre-treatment" for plants discharging incompatible wastes into a municipal sewage plant.

These revised estimates are for existing sources only; they do not account for industry growth.

Figures with asterisks include both BPT and pre-treatment costs.

1. Includes capital recovery, operating and maintenance, insurance, taxes, and energy costs. User charges for municipal treatment of waste water are not included.

2. Exclusive of aluminum.

3. Includes mechanical products.

4. Includes noncontact cooling water.

Water Quality

In a study supported by the National Commission on Water Quality, members of the Bureau staff have explored the industrial impact of Federal Water Pollution Control legislation on six manufacturing industries: petroleum refining, pulp and paper, iron and steel, nonferrous metals, textiles, and metal finishing. This project, under the direction of J. Royce Ginn, senior research staff, and Robert A. Leone, research associate, was concluded during the fall of 1975.

Perhaps the most significant and consistent empirical observation in each of the industry case studies related to the intra-industry distribution of pollution abatement costs. The research indicated that very large portions of most

industries share common costs of pollution abatement. Typically 80 percent of an industry's capacity can be treated at essentially the same cost per unit of output. The remaining 20 percent of high cost capacity is the primary source of short-run economic impacts.

In every case the 20 percent of high cost capacity represented substantially more than 20 percent of the establishments in the industry, reflecting scale economies in waste water treatment. These scale economies could create serious barriers to entry into an industry and thus might contribute to basic change in an industry's competitive structure over time.

Principles of marginal analysis suggested that price increases due to the added costs of pollution control should reflect the cost of control for the industry's marginal producer. Since very few industries are likely to experience demand reductions of up to 20 percent in response to water pollution controls, it follows that in most industries studied the marginal producer will experience higher than average costs in the short run. Consequently, consumers will face price increases in excess of the cost increases experienced by a large portion of the industry. The resulting increase in profits for firms owning those facilities that are relatively inexpensive to clean-up is an important incentive that will hasten the introduction of new capacity with low waste water treatment costs.

The research indicated that the imposition of pollution controls can lead to serious short-term capacity constraints that can easily lead to price increases well in excess of any direct cost increases associated with the controls. This particular form of impact was particularly noticeable during the period of high capacity utilization in the early 1970's indicating that the timing of pollution controls with respect to the business cycle is an important determinant of impact.

The methodological approach employed by the water quality research team has general applicability to the estimation of impacts of other types of federal and state regulation. Efforts are now underway to apply this methodology to the analysis of the impact of other government programs.

Robert A. Leone
J. Royce Ginn

Air Pollution and Health

I have analyzed health care utilization data, air pollution data, and weather data in an effort to test the null hypothesis that there is no significant association between air pollution levels in metropolitan Washington, D.C. and health effects. This research has been funded jointly by the Environmental Protection Agency and the Department of Transportation.

According to a multivariate statistical analysis of data for 1973 and 1974, there did not appear to be a significant relationship between daily photochemical oxidant readings and the number of daily unscheduled visits to four of the five clinic departments (the urgent visit clinic, internal medicine, pediatrics, and optometry) of a local group practice medical plan for which I had data. The only exception was for unscheduled visits to the ophthalmology department. There, a statistically significant relationship was exhibited between daily oxidant levels and the daily number of unscheduled visits for eye problems. The 1973 and 1974 results suggest that a ten percent increase in photochemical oxidant pollution levels was related to between a 1.0 and 4.3 percent increase in unscheduled utilization of the ophthalmology department.

I also examined the data in an effort to uncover lag or episodic effects of air pollution levels on the health care utilization; however, none were found. In this connection it should be noted that the oxidant readings included in this data were sufficiently high to trigger six air pollution alerts in 1973 and one alert in 1974 by the Metropolitan Washington Council of Governments, and were among the highest ever recorded in the area. Therefore, if the findings are confirmed by further examination of the data, it would seem reasonable to question allegations in the press that there have been significant increases in asthmatic and other respiratory complaints during the air pollution episodes.

The lack of information on the health effects of mobile source air pollutants has made it difficult to evaluate the potential benefits (including health benefits) from abatement of air pollution attributed to mobile sources. Given that the annual cost of controlling mobile source emissions from automobiles has been estimated as high

as \$11 billion by 1985, the final results of this study should be relevant for policy making in this area.

Preliminary results of this research were presented at the 69th Annual Meeting of the Air Pollution Control Association in June 1976.

Eugene P. Seskin

Property Values and the Benefits of Improved Air Quality

A number of economic tools have been used to measure the aggregate willingness to pay for air quality improvements. One technique, the opportunity cost approach, measures either the added costs associated with increased air pollution, or equivalently the reduced costs associated with air quality improvement (human health studies are one example). A second technique infers willingness to pay from analysis of the housing market, on the presumption that individuals will pay more for a unit located in an area with good air quality than for an otherwise identical unit located in an area with poor air quality. David Harrison, Jr. of Harvard University and I have investigated the methodological problems associated with this latter approach to valuing benefits. Using census tract data for the Boston housing market, and air quality data from the TASSIM model, developed by Gregory Ingram and others, we have generated quantitative estimates of the willingness to pay for air quality improvements and have tested the sensitivity of these results to alternative specifications of the basic building blocks in the procedure.

The theoretical model described in a preliminary version of the paper entitled "Housing Prices and the Willingness to Pay for Clean Air"

suggests a two-step procedure for estimating the willingness to pay for reduced air pollution. The first step is to estimate a hedonic housing price equation, and the second step is to estimate a marginal willingness to pay function for households in the urban area, a function that is analogous to a demand curve for cleaner air. Our empirical results suggest that the form of the willingness to pay curve is very sensitive to the functional specification of the housing price equation. We find that the willingness to pay for cleaner air increases with the level of pollutant concentration where the individual household resides, and that the willingness to pay curve shifts upward as income increases. We also find that allowing for the fact that the marginal willingness to pay for clean air decreases as pollutant concentrations are reduced and that willingness to pay increases with income leads to a substantially (roughly 30 percent) lower estimate of benefits when compared to the procedure that assumes that willingness to pay is independent of pollution concentration and income. We also find that specification errors in the housing price equation can alter benefit estimates even more substantially (roughly 50 percent).

Our results are preliminary because of the nature of the data and the methodology. However, we hope to pursue our research further by directing our attention to the distribution impacts of air pollution reduction programs within an urban area. We hope to take into account, as fully as possible, not only residentially oriented benefits, but also workplace related benefits and health benefits that are clearly not fully accounted for in property value studies.

Daniel L. Rubinfeld

3. HUMAN BEHAVIOR AND SOCIAL INSTITUTIONS

Introduction

Much of the Center's research is motivated by the observation that many activities that have importance for human welfare take place outside of conventional economic markets. Examples include the care of young children, health-related activities, and criminal behavior. These activities are candidates for economic analysis because they involve decision making

under conditions of scarcity. Thus, such familiar concepts as price, demand, investment, production function, and maximization through equality at the margin, can be applied to increase understanding of many important dimensions of human behavior. Not only is economics useful in studying these nonmarket phenomena, but the insights so obtained contribute significantly to the analysis of more conventional eco-

conomic problems such as the determination of wage rates, the size and location of the population, the composition of the labor force, the level of unemployment, and the rate of economic growth. These insights also prove to be valuable in the analysis of market phenomena such as the demand for medical care, which are inextricably entwined with nonmarket phenomena such as the demand for and production of health.

Many of the activities studied by the Center have consequences that extend over time. Thus the application of human capital theory and the analysis of decision making in a life-cycle context figure prominently in much of the work. The theory of the allocation of time is also an important conceptual cornerstone because the time of the participants in the activities is frequently a major input.

The work of the Center is organized in five programs: health, income distribution, law, population and the family, and taxation and social insurance. Although the programs have clear administrative and financial responsibilities, there is considerable complementarity in the substance of the work. Several members of the staff work in more than one program, and some particular studies include joint efforts. During the past year, Center staff members published 34 articles, and 24 Center working papers were distributed. The results of Center research were also incorporated in the following volumes published by the National Bureau: *Household Production and Consumption*, Nestor Terleckyj, editor; *Human Capital* (2nd ed.), by Gary S. Becker; *Economics of the Family: Marriage, Children, and Human Capital*, Theodore W. Schultz, editor.

Summaries of each program, sources of funding, and details concerning individual studies follow.

Victor R. Fuchs
Robert T. Michael

Law and Economics

Introduction

Research activity in law and economics continued at a high level during the past year. Completed and on-going studies, which are de-

scribed more fully in the individual reports below, include the following: Ehrlich's empirical work on deterrence and capital punishment; Landes and Posner's economic analysis of the independent judiciary and their quantitative study of legal precedent; Posner's study of the economic foundations of the legal doctrines of corporate finance; Peltzman's analyses of government regulation; Stigler's work on the size of legislatures and political competition, and his joint work with Becker on the increase over time in the tenure of legislators; Pashigian's economic study of bribery and his empirical research on the earnings of lawyers; Wolpin's empirical study of crime in England from 1894-1973; Heckman's development of econometric techniques for dummy endogenous variables, and his joint work with Wolpin on the empirical effects on minorities of government contract compliance programs. Fourteen papers were published this year or will be published shortly, twelve in journals and two in collections of readings.

Kenneth Wolpin joined the law and economics program this year as a research associate. Grants from the National Science Foundation and the American Bar Foundation, which is funding Pashigian's study of the legal profession, provide the support for the law and economics program.

William M. Landes

Punishment and Deterrence

I have completed an extensive study titled "Punishment and Deterrence: Some Further Thoughts and Additional Evidence." The study is in large measure a sequel to my earlier paper: "The Deterrent Effect of Capital Punishment: A Question of Life and Death," (*American Economic Review*, June 1975). The new study analyzes cross-sectional data on variations in murder, robbery, and aggravated assault and estimates the responses of these crimes to measures of deterrence, and to economic and demographic variables. The empirical results are highly consistent with, and lend strong support to, my earlier studies on crime. Particular topics addressed in the empirical investigation include: analysis of transformations, tests of stability of

sets of regression coefficients, comparisons of FBI and *Vital Statistics* data on homicide, and simultaneous estimations of sets of interrelated crimes. The theoretical analysis concerns extensions of the analysis of crime both from the offender and the public side. Optimal public defense against crime is generalized to include choices among three deterrence instruments: the probability of conviction, the extent of punishment by imprisonment, and the conditional probability of execution. The paper briefly considers the separate questions of deterrence, efficiency, and the desirability of capital punishment in light of a more general approach that includes considerations of the equity of treatment of equally guilty persons. The work also includes a critical review of some earlier studies of the deterrent effect of punishment.

Some elaborations on my paper for *American Economic Review* on the deterrent effect of capital punishment, and a response to a few critics of my work are included in two recent publications in the *Yale Law Journal*. The December 1975 issue of that journal includes my paper "Deterrence: Evidence and Inference," and the January 1976 issue includes a short rejoinder to another comment.

Isaac Ehrlich

The Independent Judiciary in an Interest-Group Perspective

This study attempts to reconcile the notion of an independent judiciary (e.g., appointment rather than election of judges, life tenure, prohibitions on nominal salary reductions) with the economic theory of the governmental process that emphasizes the importance of interest groups in the formation of public policy. An independent judiciary would at first seem to be inconsistent with and threatening to a political system in which public policy emerges from the struggle of interest groups. The outcome of the struggle could readily be nullified by unsympathetic judges. We develop an economic model, however, that shows that the independent judiciary is not only consistent with, but essential to, the interest-group theory of government. We assume that legislation is "sold" by the legislature and bought by the beneficiaries of legisla-

tion, and that substantial expenses are incurred in procuring the legislation that would not be worthwhile if the legislation were altered unfavorably or repealed within a few months or years. Two complementary methods are used to increase the permanency of legislation: legislative procedures that increase the cost of repeal (bi-cameralism, seniority, filibuster rules); and an independent judiciary to enforce legislation. An independent judiciary—in contrast to one that serves at the pleasure of the current legislature—enables an enacting legislature to make long-term legislative deals and to receive a portion of the capitalized value of the expected future returns.

We apply the model to an analysis of the form of interest-group legislation (e.g., whether annual legislative appropriations are required for enforcement), regulation by administrative agencies, differences in the selection and tenure of judges at the federal, state, and local levels of government, and the enforcement of constitutional provisions. Finally, we attempt to analyze the costs of judicial independence by an empirical analysis of the nullification of acts of Congress by the Supreme Court, and we find that the costs of nullification have tended to be slight (97 nullifications out of about 38,000 acts). We also examine the effects of the age and tenure of judges and other variables on the likelihood of nullification.

This study is detailed in a paper prepared for the Universities—National Bureau Conference on the Economic Analysis of Political Behavior and was published in a special issue of the *Journal of Law and Economics*.

William M. Landes

Richard A. Posner

The Economics of Legal Precedent

Although the use of precedents as a technique for creating specific rules of legal obligation is a fundamental characteristic of our legal system, it has not been studied scientifically. No one knows, for example, what the effective stock of legal precedents is in various areas of the law; whether the importance of precedent in the decision of cases is increasing or decreasing; whether precedent is more important in the

Supreme Court or lower courts; whether administrative agencies use precedent to any significant extent; what the rate of obsolescence of legal precedent is in various areas of the law; whether more general precedents obsolesce at a slower rate than more specific ones; and whether increases in legislative activity increase the rate of obsolescence of legal precedents. We believe these questions can be examined by the theoretical and quantitative tools of economic analysis.

The theoretical framework of our study is derived from the economic theory of capital. We treat the body of legal rules as a stock of capital that depreciates over time due to changes in social and economic conditions, in legislation, in judicial personnel, and in other parameters of legal action. The stock can be augmented and depreciation offset by investing in developing new precedents and modifying old ones; for example, by litigation at the appellate level. We develop a model of the optimal accumulation of legal capital that relates investment and the stock to the value of legal capital, the costs of producing precedents, and the rate of depreciation. We further derive the relationship among the average age of precedents, the growth rate of precedents, and the depreciation rate.

Our main contribution is the empirical analysis of precedents. The basic data are case citations in judicial opinions. Although a case citation is not the same thing as a precedent (since a case is not always cited for its precedential significance) it is a good proxy because it affords a convenient basis for quantitative analysis. By combining data on the age of citations with estimates of growth rates of precedents, we are then able to calculate, and test hypotheses on, depreciation rates of Supreme Court and lower court precedents by subject matter classes (e.g., torts, tax, antitrust, civil rights, etc.). Since data on citations are not compiled, it is necessary to create a data base by reading thousands of decided cases and recording the essential information about each case (subject matter, age and number of citations to earlier precedents, use of this case as a precedent in later cases, etc.). We have developed one data base consisting of a sample of 1974 and 1960 U.S. Court of Appeals and Supreme Court cases

where citations to earlier cases are recorded, and are in the process of developing two others: a sample of 1900, 1938, and 1955 Supreme Court cases in which citations to these cases are tabulated; and an annual sample of U.S. Court of Appeals cases from 1890 through 1975. We have completed a draft of a paper using the first body of data, that will be published in the *Journal of Law and Economics*.

William M. Landes
Richard A. Posner

Economic Approach to Law

I have completed a review essay, published in the *Texas Law Review* (Vol. 53, p. 757, May 1975), that surveys the literature on, and explains and defends, the economic approach to the analysis of law. The origins of the economic approach, its major findings to date, the principal criticisms of the approach, suggestions for additional research, and pedagogical issues raised by the new approach are the principal topics discussed. The paper was originally given as the Orgain Lecture at the University of Texas Law School, and received the First Annual L&EC (University of Miami Law and Economics Center) Prize for Distinguished Scholarship in Law and Economics.

Richard A. Posner

The Legal Rights of Creditors of Affiliated Corporations

In this paper, which will appear in the *University of Chicago Law Review*, I use economic theory to examine a recurrent problem in legal analysis: to what extent should an investor be permitted to limit his liability to creditors to the amount of money that he has invested in a venture? Specifically, if one corporation owns another, can the creditors of the second ("affiliated") corporation reach the assets of the first for any unsatisfied claim, or does the traditional doctrine of the corporation's "limited liability" (i.e., shareholder nonliability for the corporation's debts) insulate the first corporation from liability?

It turns out that the economic analysis of corporate finance supplies answers that are somewhat different from those of contemporary legal

scholarship. I show in this paper that limited liability is not, in general, a device for externalizing the costs of business ventures. On the contrary, the doctrine of limited liability serves to minimize financing costs by, among other things, permitting an optimal sharing of risks among creditors and investors. Thus, as in many other areas of law, economic analysis furnishes a justification for traditional legal doctrines that legal scholars not using economic tools have found difficult to defend.

I also show that the doctrine of limited liability should, in general, be adhered to in the case where the shareholder is another corporation rather than an individual, save where the shareholder has been misled into thinking that the corporation-shareholder was the real debtor or had pledged its own assets to satisfy the debt. Since this is the dominant approach taken by the law in answer to the question of creditors' rights in affiliated corporations, once again economics furnishes a rationale for a traditional legal approach.

Although the issues addressed in this paper are narrow ones, the general approach of seeking to explain legal doctrines in the areas of corporate finance, bankruptcy, and related fields on the basis of the economic principles governing lending and investing seems a promising one that can be applied more widely.

Richard A. Posner

Economics of Regulation

I have completed a paper entitled, "Toward a More General Theory of Regulation," in which I demonstrate that special-interest theories of regulation (e.g., regulation as cartel formation) cannot be generally valid. A rational regulatory process pays heed to multiple interests. From this several hypotheses about regulatory behavior are deduced—for example, that regulated prices and profits are negatively correlated, that regulators seek out technologically progressive and growing industries to regulate, etc. The paper will be published in the *Journal of Law and Economics*.

I am also working on a study of the effects of industrial concentration. The goal of the project has been to isolate two potential effects of

changes in market concentration—cost and price effects—in order to examine the efficacy of legal restraints and regulation of concentration. Most of the empirical work is complete and a tentative conclusion has been reached that shows that cost effects of changing market structure are (a) empirically important and (b) more important than price effects.

My article "The Effects of Automobile Safety Regulation," that was described in last year's annual report, was published in the *Journal of Political Economy*, August 1975.

Sam Peltzman

Political Competition

The fact that all governments face various forms of competition from other governments is a platitude. Indeed, a fairly extensive literature has grown up in the last two decades about the "Tiebout hypothesis," which argues that under certain restrictions, the competition of local governments will lead to optimal supplies of local public goods.

However, little explicit attention has been devoted to the question of what constraints the direct competition for citizens and tax capacity and the indirect competition for national markets have placed on the regulatory process of various levels of government. This is the focus of the work which I have recently initiated. I am presently exploring both the relevant trade literature and some empirical studies of state regulation.

My paper "The Size of Legislatures," which was summarized in last year's annual report, was published in the *Journal of Legal Studies*, January 1976.

George J. Stigler

The Professionalization of Politics

There has been a remarkable increase in the average tenure in office of congressmen in the United States. For example, the average number of terms of service never rose to 3 before 1900, but never fell below 3 thereafter and has steadily risen to nearly 6 in recent years. We plan to measure this phenomenon more precisely and for a variety of legislatures, and then seek expla-

nations for the trend in the comparative economic advantages of the political calling.

Gary S. Becker
George J. Stigler

On The Control of Bribery and Crime

The effect of a fine for bribery and a fine for crime on the amount of bribery and crime is analyzed in this paper. Past studies have often separated the bribery problem from the crime problem. However, penalties for one form of illegal activity will generally have an effect on the quantity of other forms of illegal activity. In this paper I develop a theory in which crime and bribery are interrelated. The bribe offered by an apprehended criminal depends on the expected reduction in the fine for the crime which in turn depends on the severity of the crime committed. The selection of crime severity will depend on the expected cost of bribery. The comparative effects of a change in the fine for bribery and the fine for crime on the amount of bribery, the crime rate, and the severity of crime are developed. The paper was published in the June 1975 issue of the *Journal of Legal Studies*.

B. Peter Pashigian

The Demand and Supply of Lawyers

During the past year, I developed a theory of the number of practicing lawyers and a data base to implement a time series analysis of the number of lawyers from 1920 to 1970. The model uses the human capital theory to determine equilibrium earnings in the legal profession. The theory of rational expectations is used to determine the required number of entering first-year law students consistent with equilibrium expected earnings in the legal profession three years hence. The change in the actual number of first-year students enrolled in law schools is assumed proportional to the difference between the required number for equilibrium and the current number of first-year students.

Some preliminary empirical results indicate that the earnings of lawyers exceeded the equilibrium earnings from 1929 to the mid-1950's. Since the early 1960's a gap between actual and equilibrium earnings has reappeared and

explains the increased interest in the study of law. Regression results suggest that the underlying determinants of the demand for lawyers are real income, the number of corporations, and judicial activity as measured by the number of court cases and bankruptcies. The time series results show the number of lawyers decreases with increases in alternative earnings. The estimates of the speed of adjustment to equilibrium appear to be relatively low.

B. Peter Pashigian

An Analysis of Crime in England: 1894–1973

There have been a number of recent empirical attempts to quantify the relationship between criminal activity and law enforcement. The evidence indicates important deterrent effects of the criminal justice system. Most of this research has been confined to cross-sectional data sets that ignore spillover effects caused by the mobility of criminals. Moreover, the proxies alleged to capture deterrent impacts have been imperfect. In particular, alternative forms of punishment have not been available, and the effects of apprehension have been confounded with punishment effects. In addition, societal responses to exogenous changes in criminal activity are difficult to ascertain from cross-sectional data.

My research in this area concerns an analysis of crime in England for the period 1894–1973. I have gathered published data for approximately 15 specific crimes ranging from the more severe crimes of murder, manslaughter, and wounding to the less severe such as pick-pocketing and shoplifting. For each crime the following information has been collected: the number of offenses known to the police, the number of known offenses for which the offender is apprehended, the number of those apprehended who were ultimately convicted, the type of punishment—fines, probation, whipping, reformatory, or imprisonment, and the length of the imprisonment. Further, variables on police activity such as the actual number of police by rank, their total salaries, total expenditures on police and the average length of service in the police force have been obtained. To complement this data set, I have collected economic

and demographic information for the population including, for example, unemployment rates, age distribution, and urbanization.

Although the analysis is at the preliminary stage, it appears that the economic approach to crime can aid in our understanding of the pattern of crime over this period. In addition, this approach seems to be a fruitful avenue for discerning and rationalizing the temporal patterns of police activity and its relationship to crime as well as changes in the types and severity of punishment through time.

A future goal of this research is to understand the causes of international disparities in crime. The main question to be addressed concerns the role of deterrents as opposed to inherent population characteristics in determining the extent of criminal behavior. Although a comparison of the British to the U.S. data would be informative, data from other, less similar, cultures will be explored.

Kenneth I. Wolpin

Dummy Endogenous Variables

Recent work on law and economics has begun to focus on the causes of legislation and not simply the economic consequences of legislation. Two important issues arise: (1) What factors determine the passage of a law? (2) What is the effect of endogeneity of laws on the measurement of the effect of laws on economic indicators?

This year, I have written two papers that address these questions within the specific context of the Landes (*Journal of Political Economy*, 1968) study of fair employment legislation. In the course of answering those questions, I develop an econometric methodology for estimating simultaneous equations systems with both continuous and discrete endogenous variables. In one paper "Dummy Endogenous Variables in a Simultaneous Equations System" (forthcoming in *Econometrica*) the methodology is developed. In a comparison piece "Simultaneous Equations Models with both Continuous and Discrete Endogenous Variables with and without Structural Shift in the Equations" in Richard Quandt, ed., *Studies in Nonlinear Estimation* (Cambridge, Mass.: Ballinger, 1976), a class of

simple estimators is developed and applied to the Landes data.

The principal substantive findings are: (1) a tentative equation predicting passage of a fair employment law can be readily estimated and is found to be economically meaningful; (2) explicit treatment of the presence of a law as a dummy endogenous variable causes the Landes (1968) fair employment law dummy to become numerically and statistically significant. Linda Edwards has applied the same methodology, with success, to an analysis of compulsory schooling laws.

James J. Heckman

Analysis of Federal Contract Compliance Programs

We have used Chicago data to analyze the effect of the Office of Federal Contract Compliance (OFCC) on upgrading the status of minorities. The work is in two parts. In Part One we develop a model of firm contract receipt and retention procedure. We stress that the voluntary nature of contract awards implies that contractors and noncontractors are likely to differ in their employment practices toward minorities even when the program has had no effect on minority status. Hence, contractor-noncontractor differentials measured in the ordinary way afford no guide to the effect of OFCC on minority status. In Part Two we present estimates of the effect of OFCC on minority status using a methodology that circumvents the bias discussed in Part One. We find strong evidence for the existence of program effects on minority status. Further, we find that firms with higher per-contract minority composition are more likely to receive contracts. There is no evidence of a systematic contract compliance review policy by the government. This work is reported in two articles: "Does the Contract Compliance Program Work? An Analysis of Chicago Data" (*Industrial and Labor Relations Review*, August 1976) and "An Analysis of the Change in the Position of Minorities 1966-1974" (*Explorations in Labor Economics*).

James J. Heckman
Kenneth I. Wolpin

TABLE II-6

Time Uses

| Location | Activity | | |
|-----------------|---|--|---|
| | Working | Investing | Consuming |
| Labor market | Producing goods or services for remuneration Commuting | Job searching On-the-job training | Obtaining direct utility from work Leisure time at work |
| Nonlabor market | Housework Child care Shopping | Schooling Recuperating Tending capital investments Moving | Leisure Satisfying biological needs (sleeping, eating, etc.) Volunteer work |

Income Distribution

Introduction

A unifying theme of this research program is that the distribution of income is influenced in two important ways by individual decisions concerning the allocation of time. First, in a static context, time can be spent in any of several activities; the way time is used directly affects the distribution of income among individuals, workers, and households. The hypothesis maintained throughout much of this research is that the allocation of time is responsive to price incentives. The research measures the price-responsiveness of time uses under various circumstances. The vector of prices is viewed as affected by the structures of households, industries, government tax and transfer systems, and by the level of business activity, technology, and social mores. The uses of time are often distinguished either by the location of the activity (in or outside of the labor market) or by the nature of the activity (working, investing, or consuming). Each type of activity can be undertaken in either location as suggested by the taxonomy in Table II-6.

Second, decisions concerning the allocation of time in one time period significantly affect both the price incentives for time use in subsequent periods and the distribution of income in subsequent periods. Considering the effects of current time use on future opportunities provides important insights. Prospectively, they help us understand why time is allocated as it is (for example, over the lifetime among working, investing, and consuming); retrospectively, they permit

researchers to view the current price vector (in particular the wage rate) as the cumulative result of how time was allocated in previous periods. Since, through their allocation of time, individuals can forego income in one period in behalf of another period, the observed distribution of current income does not necessarily reflect the underlying distribution of well-being.

Individuals differ both in their ownership of income-producing assets at one point in time and in their opportunities for altering the stream of income over time from any given bundle of initial assets. Genetic endowments, family background, access to funds, luck, and time-allocation decisions in previous periods, all affect the current period and the lifetime distributions of "income," however defined. In the studies detailed below, issues related to both the allocation of time and the resulting distribution of income are discussed. In some a static framework is used; in others a more dynamic, time-dependent context is employed. Several address issues related to the causes or consequences of differences among individuals in their ability to alter the structure of their income-generating assets.

In many of the studies longitudinal data is utilized. These include the National Longitudinal Surveys, the Michigan Income Dynamics Survey, the Coleman-Rossi Continuous Retrospective Work Histories, and the NSF Register of Scientific and Technical Personnel. In our program, increasing attention has been paid to econometric techniques that exploit the longitudinal nature of these data files.

Since last year's report, Reuben Gronau has

joined the staff of our income distribution program, on leave from Hebrew University for the year. We also have two NBER Research Fellows this year: Oey Astra Meesook from Thammasat University, Bangkok, Thailand, a Rockefeller Foundation Foreign Research Fellow; and Donald O. Parsons from Ohio State University, the NBER's Harry Scherman Research Fellow.

Research output from this program area during the past year includes eight NBER Working Papers:

Ann P. Bartel, "Job Mobility and Earnings Growth," Working Paper 117, November 1975.

Edward Lazear, "Schooling as a Wage Depressant," Working Paper 92, June 1975.

_____, "Human Wealth and Human Capital," Working Paper 97, July 1975.

_____, "Education: Consumption or Production," Working Paper 104, September 1975.

Lee A. Lillard, "Inequality: Earnings vs. Human Wealth," Working Paper 80, April 1975 (*American Economic Review*, forthcoming).

_____ and Yoram Weiss, "Analysis of Longitudinal Data: American Scientists 1960-1970," Working Paper 121, January 1976.

Donald O. Parsons, "Health, Family Structure and Labor Supply," Working Paper 132, April 1976.

Yoram Weiss, "The Earnings of Scientists, 1960-1970: Experience, Age and Vintage Effects," Working Paper 99, July 1975.

Kenneth Wolpin, "Education and Screening," Working Paper 102, August 1975 (*American Economic Review*, forthcoming).

In addition, the following papers have been or will soon be published:

Victor Fuchs, "A Note on Sex Segregation in Professional Occupations," *Explorations in Economic Research*, 2: 1, Winter 1975.

Isaac Ehrlich (with Uri Ben-Zion), "Asset Management, Allocation of Time and Returns to Saving" (revised Working Paper 71), *Economic Inquiry*, June 1976.

James Heckman, "A Life Cycle Model of Earnings, Learning and Consumption," in *The Journal of Political Economy*, 1976.

Jacob Mincer, "Progress in Research on the Distribution of Earnings," in *Personal Distributions in Incomes*, Royal Economic Society, 1976.

_____, "Unemployment Effects of Minimum Wages," (Working Paper 39), forthcoming in *The Journal of Political Economy*, 1976.

Yoram Weiss, "The Wealth Effect in Occupational Choice," (revised Working Paper 25), in *International Economic Review*, June 1976.

_____ (with A. Blinder), "Human Capital and Labor Supply: A Synthesis," (revised Working Paper 67), in *The Journal of Political Economy*, April 1976.

The Center's research on income distribution is supported by the National Science Foundation, The Rockefeller Foundation, and the U.S. Department of Labor.

Robert T. Michael

Earnings Structure in the U.S.

During the past year research continued on the determinants of the structure of earnings in the U.S., utilizing the Coleman-Rossi Retrospective Life History Study and the NLS (National Longitudinal Survey) retrospective and panel surveys.

Although the traditional factors affecting earnings, such as education, ability, and family background are not neglected in our current research, we are concentrating primarily on the influence of several aspects of work experience on both changes in earnings over the life cycle and differences in earnings among individuals. The aspects of work experience we are exploring are: (1) progress on the job within a firm (including training, learning, occupational promotion, and wage growth); (2) job mobility, both local and geographic; (3) weekly and annual hours of work; (4) the incidence and duration of unemployment, and its relation to job search and to labor mobility.

Ann Bartel reports in detail on the effects of job tenure and job mobility as observed in the Coleman-Rossi data. Some of the more important general conclusions are:

1. Job mobility contributes less to individual wage growth than does job progress within the firm. Mobility is, however, comparatively more important at lower levels of education and, of course, in the earlier years of experience. Both forms of human capital investment continue at progressively reduced rates throughout the working life. It appears that "successful" job searchers ultimately land jobs in which their

earnings grow faster than the earnings of those whose mobility continues. Thus, greater mobility beyond the early years of work experience is likely to reflect an adverse selectivity in the labor market matching process: the persistently mobile worker exhibits a slower wage growth and a lower level of earnings by mid-career. These workers are more heavily represented in the less educated groups, but the finding persists within education groups as well.

2. Wage gains from job change depend on the amount of job information available to the potential job changer at the time of separation. In the Coleman-Rossi sample, over 70 percent of those who quit but less than 25 percent of those laid off had relevant job information. Correspondingly, the average gain from mobility was greater for job changers who quit. Evidently, search before separation affects both the separation and the wage gain while the observed adverse effect of unemployment on wage gain is in part a consequence of less information available to the unemployed at the time of separation.

The analysis of labor mobility was carried out separately for whites and blacks in the Coleman-Rossi data and replicated to a limited extent on the NBER-Thorndike-Hagen sample. Presently, we are starting a comparable and more thorough analysis of labor mobility and its effects on earnings in the NLS samples of older and of young men.

Geographic mobility is a component of labor mobility to which we devoted special attention in view of the richness of individual data not previously available. A theoretical analysis focusing on the family as a decision-making unit and some of the empirical implications are spelled out in my preliminary paper "Family Migration Decisions." Ann Bartel's companion paper describes some findings from the Coleman-Rossi data. Gains from and the extent of geographic mobility depend on family status. Mobility is greatest among divorced and separated males, smallest among married men whose wives work and who have school-age children. Gains are largest for those whose wives lost employment by migrating and for those who are transferred by the firm. The latter tend to be more educated; otherwise education appears to have no effect

on migration, holding work experience constant. This appears to contradict other findings in the literature, at least in part, because no such standardization was previously possible. This and other puzzles should find some resolution in the replications underway using other data sets.

The analysis of hours of work was conducted mainly by George Borjas, using the National Longitudinal Survey of Mature Men. This data set contains considerable information on measures of labor supply and earnings. Previous studies of the determinants of hours of work have been plagued by a negative, spurious correlation between hours of work and the wage rate. This resulted from the necessity of measuring the wage rate by dividing annual (or weekly) earnings by annual (or weekly) hours: any measurement error in hours was present in both the dependent and the independent variable, imposing a negative correlation. We have utilized the NLS data to construct measures of the wage rate that do not depend spuriously on the dependent variable, weekly hours. This was accomplished by using two NLS measures of hours (usual and current) as well as the longitudinal history of wage rates. Once we defined the wage variable independently of hours worked weekly, we found that the negative wage elasticities that are prevalent in the literature vanish. The adjusted estimates of the wage elasticities are positive and significant. Thus it is likely that the substitution effect outweighs the income effect. For this (and other) reasons these cross-section results provide no evidence to support the backward bending labor supply curve hypothesis. Moreover, we estimated that about 30 percent of the variance in reported hours represents error. The same is consequently true of the variance in hourly earnings, with obvious implications for the maximal explanatory power of statistical wage functions. We have also analyzed multiple job holding and overtime hours, and are currently undertaking a study of the determinants of changes in hours over time by utilizing the panel information in the NLS.

Annual hours of work depend on weekly hours and on weeks worked during the year. The latter are the complement of time spent either out of

the labor force or in unemployment. Preliminary work on the Coleman-Rossi data by Linda Leighton provides estimates of individual probabilities of ever being unemployed (over the first one-and-a-half decades of work experience) and estimates of durations and frequencies of unemployment episodes. Some of the preliminary results are as follows. Roughly 36 percent of the black and 25 percent of the white subsample reported at least one incident of unemployment over their work history (an average of fifteen years' experience). We find that the probability of being unemployed declines over experience-intervals and, within each interval, declines across schooling levels. Average duration of unemployment also declines across schooling levels, but no pattern emerges over experience intervals. These results hold for both racial groups.

As the Coleman-Rossi data set is retrospective, our next step is to examine some of the panel data such as the National Longitudinal Survey of Mature Men and of Young Men, and to study both the determinants and effects of unemployment on earnings.

Finally, a start was made on the study of the distribution of longitudinal earnings profiles in the Coleman-Rossi data. We are estimating distributions of individual parameters such as initial earning capacities prior to schooling and experience, post-school investment parameters, and rates of return. The analyses of the contribution of each parameter to interpersonal differences in earnings and of the determinants of these parameters are currently under way. Two fragmentary findings are the following. As much as a half of the residual of the cross-section earnings function at "overtaking" (about nine years of experience) is due to differences in measured earnings capacity, a factor which persists at each level of experience. Also, estimates of early post-school investment are positively related to subsequent wage growth.

Jacob Mincer

The Effects and Determinants of Labor Mobility

During the past year my research has been concerned with an analysis of the effects and determinants of labor mobility. The Coleman-Rossi

Retrospective Life History Study provides a rich data set for this study since it contains information on the duration and starting and ending salaries of each job the individual held from the time he first entered the labor force until the date of the interview (at which time the men were approximately 35 years old). A lifetime accounting of geographic mobility, marital status, and wife's employment history is also provided. The important findings on the effects of labor mobility on the earnings growth of the Coleman-Rossi white males can be summarized as follows (for more detail see my NBER Working Paper 117):

1. When post-school earnings growth was decomposed, 87 percent of the price-deflated earnings growth of an average 35-year-old white male was found to occur on the job, with the remaining 13 percent being due to job mobility. These percentages were not constant across education groups; the grammar school group had the largest proportion of earnings growth due to mobility (24 percent); the graduate school group had the second largest percentage (16 percent).

2. More mobile individuals (i.e., individuals who had worked at several firms) had significantly lower earnings gains in the long-run than the less mobile, education and experience held constant. It was also found that individuals who had worked at more than one firm and had their longest tenure at the current firm had larger total earnings growth and higher current earnings than either those individuals who had worked at only one firm or those who had worked at several firms and had been at their current job a relatively short time. In other words, mobility was found to be more beneficial if it occurred early in the individual's working life.

3. The effect of geographic mobility on earnings growth was also analyzed. If the individual moved to a new state without changing employers, his earnings at the firm grew faster than if he had not moved geographically. However, if geographic mobility accompanied interfirm mobility, the increment in the individual's earnings due to the change in firms was lower. One explanation for this finding may be that while intrafirm geographic mobility is usually a method of promotion, interfirm geographic mo-

bility may not always be made in the interest of the individual's earnings gain; the latter may involve nonpecuniary considerations or may represent pecuniary gain to the family but not necessarily to the individual.

In order to get a more complete understanding of the effects of migration on earnings, I have recently begun a study of the determinants of geographic mobility in the hope that this will lead to a clearer picture of the process by which migration affects both the individual's and the family's earnings.

Ann P. Bartel

Income Distribution in Thailand

During my year at NBER as a Rockefeller Foundation Foreign Research Fellow, I am pursuing my study of the impact on the distribution of income in Thailand of various government policies that are being implemented or considered. These policies concern population growth, education, wages, prices, wealth, taxes, and consumption expenditures. Given an interest in the quantity of goods and services available to each individual in the total population, income inequality will be measured in terms of household income per person (or per adult-equivalent). In the agricultural sector, household income will include both cash income and own consumption, the latter being a significant proportion of the total in that sector.

Despite interest in the impact of government programs on individuals, I cannot disregard the important role of the family or the household. The household is relevant in a definitional sense, as several of the social indicators which I intend to study are household-specific, e.g., per capita income will be defined as household income divided by the household (adult-equivalent) size. More fundamentally, the household is an institution through which much relevant behavior is influenced; for example, differences among people in the use of time in labor force, home work, and schooling activities (and thus both current and future money income) are affected by household structure. Furthermore, the importance of the household in affecting behavior implies that the impact of government programs on individuals depends critically on how these programs are translated through the institution

of the household. For example, the efficacy of family planning programs will depend on the existing structure of households and their impact will surely differ among individuals in different types of households. Or, regarding tax policies, the personal income tax with its structure of personal exemptions, is directly affected by family size and composition.

To take account of the important interrelationships among factors influencing the distribution of household income per person, I required detailed information on each of the individuals in each household. The 1968–1969 Socioeconomic Survey for Thailand contained data for a national sample of about 13,500 households. The data include the region and area of residence for each household, the consumption of various categories of goods and services (both purchased and home produced), the ownership of consumer durables, changes in household assets and liabilities, and the age, sex, marital status, level of educational attainment, occupation, income, and relationship to family head for each household member.

A random subsample of this survey will be used for my study. Behavioral relationships will be estimated from various sources and used to simulate the behavior of households over a series of time periods.

The behavior is partitioned into several blocks which will be dealt with in a block recursive model. The blocks encompass demographic, education, labor force, income, and consumption/savings components. After the model has been estimated, the impact of various governmental policies will be simulated.

My work to date has focused mainly on estimating the demographic and education blocks, and is nearing first-round completion. So far, attention has been given mostly to the technical aspects, the testing being carried out on a small sample with crude estimates of the relevant parameters. At the same time, behavioral relationships are also being collected or estimated, and these will be included later. The model will have to be constructed, at least to the labor force participation block, before even preliminary results will be available.

Oey Astra Meesook

The Production of Wealth

This year I completed my study "Education: Consumption or Production" (NBER Working Paper 104), in which I developed a model in which education affects the individual's welfare in two ways. Education affects ability to earn wages in the usual sense and also enters the utility function directly because of the consumption aspects of education. The model treats education as a joint product and permits the estimation of both the rental value of a unit of education used in the labor market and the education parameter in a utility function. In addition, the effects of differences in IQ and family background on optimal investment and consumption of education can be determined. The major finding of this study is that education is a "bad"; it enters negatively into the individual's utility function. Using a sample of young men from the National Longitudinal Survey, I found that: (1) the wealth-maximizing level of education exceeds the attained level for 97 percent of the individuals; (2) parental education affects initial wages (schooling costs) by much less than it affects the returns to education; thus, both actual and wealth-maximizing levels of education are positively related to parental schooling; (3) IQ, on the other hand, affects the costs and returns to schooling proportionately; (4) the rental price of education is positive and substantial; and (5) the implied wealth-maximizing level of education is sixteen years for the mean individual while the actual level achieved is twelve years. Specification changes were made to test the model's robustness. Under varying cost and returns functions, the results were qualitatively always the same.

A related paper currently in progress is titled "Family Background and Optimal Schooling Decisions." This study examines the differences in attained educational levels across groups and considers possible explanations for these differences. Specifically, educational attainment is correlated with family background variables, particularly race and parental wealth. Would these differences exist in a world of perfect capital markets or do they reflect differential access to funds across groups? If imperfect capital markets impede the ability of certain groups to

optimize in their choice of schooling levels, the wealth of these individuals can be more efficiently increased by government measures designed to insure access to funds. On the other hand, differences in schooling levels may be optimal (in a perfect capital market sense) because of differences in costs and returns to schooling across groups. If the latter is the case, the wealth of disadvantaged groups is more efficiently increased by reducing discrimination in the labor market rather than in the capital market. In a related question addressed in the study, I examine the way in which ability affects the probability of choosing the optimal level of education rather than some sub- or super-optimal level.

In a third paper (also in progress) I consider intergenerational externalities and question whether a parent will underinvest in the human capital of offspring as the result of uncertain repayment. An externality is generated if the child is willing to compensate a parent for investment undertaken when he or she is young (or unborn); however, the parent may fail to make that investment because an enforceable intergeneration contract cannot be negotiated. The size of any externality can be estimated, and the model can be extended to analyze such phenomena as child neglect. I am currently pursuing this line of investigation.

Edward Lazear

Asset Management and the Allocation of Time

In my paper, "Asset Management, Allocation of Time, and Returns to Saving," co-authored with Uri Ben-Zion, we have extended Alfred Marshall's distinction between "gross" and "net" interest on capital. While recognizing that gross interest typically includes some insurance against risk, Marshall also stressed that it includes "earnings of management for the task, which is often very arduous, of keeping these risks as small as possible" and that in some cases it may consist almost entirely of "earnings of a kind of work for which few capitalists have a taste" (Marshall, *Principles of Economics*, 8th edition, New York, Macmillan, pp. 589, 591). While Marshall ascribed the willingness to devote resources to management of capital assets

to individual preferences, we suggest that this willingness is negatively related to the individual's management costs and positively related to his expected gains. Also, while Marshall stressed the relevance of "net" interest as a measure of the reward of capital, we show that for a wide range of decisions pertaining to the allocation of productive and consumptive resources over the life cycle, gross interest is the relevant determinant.

The basic implications of the paper concern the interdependencies between consumption and production activities on the one hand, and the allocation of working time between conventional work and asset management on the other. The analysis shows that households may make different consumption and saving choices, not necessarily because of differences in *subjective* discount rates or "time preference," but because of differences in gross rates of return to capital due to differences in endowments of human capital, nonhuman capital and abilities. Investors are considered "financial intermediaries" who often borrow not for the purpose of financing current consumption needs, but for the purpose of extending their nonhuman capital holdings in light of their optimal allocation of resources to asset management. The analysis further examines the interaction between changes in accumulation of nonhuman capital assets and labor market decisions over the life cycle. Decisions regarding salaried versus self-employed work and regarding "retirement" from the labor force are in part a function of the incentives to devote more resources to the management of nonhuman capital assets. The analysis predicts differences in average propensities to save across occupational and income brackets and briefly examines these predictions in light of previous theoretical and empirical findings.

Issac Ehrlich

Determinants of High School Attrition Behavior

During the past year I have continued my study of high school attrition behavior in the United States. The decision to drop out of school is viewed in an expected value framework, where

the net gain from completion varies with differing rates of unemployment for dropouts and graduates, the present value of the anticipated graduate/dropout lifetime earnings differential, and the costs of the additional schooling.

My empirical research distinguishes the significance of race, sex, academic ability, family background, high school characteristics, and labor market variables 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. Cohorts of students are followed from matriculation through completion of high school, allowing for the analysis of the timing of the dropout decision across race and sex groups. My results indicate that differentials in dropout rates are considerable by race for each sex, but are not significantly different by sex within race groups. Although the magnitude of the black dropout rate exceeds that for whites, the timing pattern of dropout behavior over the high school years is remarkably similar for blacks and whites. Young women are slightly less likely to drop out of high school than are young men, yet they are also less likely to attend college; hence there is less variation in ultimate educational attainment among young women than among young men. Furthermore, for blacks and whites, males are more likely to have had no high school experience than are females.

A conditional logistic maximum likelihood model is used to estimate parameters of attrition behavior. My findings indicate, for example, that the positive effect of mother's education on completion decreases with every successfully completed year of high school, while the predictive value of student's academic ability increases throughout the high school years. The logistic model uncovers the nonlinear effects of changes in the independent variables on the estimated probability of attrition. For example, a one standard deviation increase in student ability (measured by an IQ test score) increases the probability of high school completion by 9.9 percent for black males, whereas a one standard deviation decrease in IQ score decreases completion propensity by 19.9 percent. For white males, these figures are 2.9 percent and 8.1 percent, respectively. Similarly, for black males a

one standard deviation decrease in mother's level of education has a far stronger effect on dropout behavior than does an increase; for whites, the effects are symmetrical and are significantly smaller. The overall predictive power of the model appears to be quite good, with predicted and actual dropout rates differing by less than 10 percent.

A preliminary version of my results was presented at the Educational Testing Service/National Bureau of Economic Research Conference on Current Research in the Economics of Education in October 1975. The completed study will be submitted as my doctoral dissertation at Teachers College, Columbia University.

Kathleen V. McNally

The Earnings of Scientists 1960–1970

In this study I analyze the earnings data that scientists reported to the National Science Foundation's (NSF) National Register of Scientific and Technical Personnel during the period 1960–1970. My data include information on scientists in several fields: agriculture, biology, chemistry, earth sciences, mathematics, physics, and psychology.

I have worked with a simple theoretical model of investment in human capital that can be solved in closed form. The model's solution is used to generate an earnings function that is estimated and used to analyze the data. The analysis breaks earnings differentials into differences in initial level, i.e., starting salaries, and differences in the growth in earnings thereafter.

One of the most important factors that determines the level of starting salaries is the year in which the scientist entered the labor force. Real starting salaries grew on average by 2.3 percent per annum during the decade. Growth was sharper at the beginning of the decade, indicating changing market conditions. The average growth in starting salaries was higher in academic institutions than in private industry by one percentage point per annum. Growth in starting salaries was fairly uniform across level of highest degree (Ph.D. vs. B.A.). Comparing across fields, the greatest growth in starting salaries was found in biology and the least growth in physics.

Two other major sources of differences in

starting salaries are associated with the choice of employer and level of schooling. Choosing 1970 as a reference year, I found that a scientist with a Ph.D. could increase his starting salary by 28 percent if he chose to work in private industry (this differential was almost 40 percent in 1960). A scientist who planned to work in private industry and who acquired a Ph.D. (at age 26) had a 42 percent higher starting salary than a B.A. (at age 22).

Differences in starting salaries across fields appear to be relatively less important. Again using 1970 for comparison, I found that scientists with a Ph.D. (age 26) employed in academic institutions could expect the highest starting salaries in psychology. The lowest starting salary was in chemistry with a difference of 18 percent. As with type of employer differences, there is an interaction with time, and some fields changed their relative positions during the decade.

One of the main lessons to be learned from the human capital approach to the analysis of earnings is that focusing on starting salaries to the exclusion of later effects of individual choices may generate highly misleading conclusions. Generally, some trade-off between current and future earnings would be expected, and it is therefore important to examine the effects of the various explanatory variables on the slope of the earnings profile. I found that:

1. Holding time effects and other variables constant, younger scientists enjoyed a higher rate of growth in earnings during the decade, indicating a higher rate of investment in human capital.

2. Holding experience constant, scientists with more recent vintages received a higher rate of growth in earnings, thus indicating higher investment in on-the-job training. These vintage effects varied in strength across fields and level of schooling. They were pronounced for Ph.D.'s in physics, but weak for those in agriculture and psychology. They were absent among B.A.'s.

3. Scientists with higher levels of schooling, and/or higher "quality" schooling tended to have steeper profiles, again indicating a higher rate of investment.

4. Scientists in academics had steeper profiles than scientists in private industry.

Combining these results with the previously mentioned differences in starting salaries, I found that some differences are likely to be compensated, in the sense that lower starting salaries are associated with higher gains from experience. This is true with respect to differences by employer, and also with respect to some differences by field. Thus, in agriculture and psychology I found relatively high starting salaries associated with small gains from experience. In other fields, such as biology and physics, on-the-job training appears to be more prevalent, and low starting salaries are associated with high gains from experience. Other differences are not compensated in that sense; for instance, vintage effects increase both the level and the slope of the earnings profile. But, of course, compensation is more likely with respect to individual choice variables.

Among the important implications of the study is that cross-section earning profiles differ systematically from actual individual profiles. The differences are due to the above-mentioned shifts in the level and slope of individual profiles. Thus, considerable differences arise in prediction of earnings from a single cross section and from a pooled cross section such as the present study. For instance, consider a scientist of 1948 vintage who had 12 years of experience in 1960. His 1970 real earnings would be underestimated by 35 percent if we use the earnings of a scientist with 22 years of experience in 1960. Some of this difference is due to uniform growth in productivity, but about one-fourth is due to vintage effects. More generally, the time effects were not uniform across levels of experience and schooling; thus a simple uniform correction for growth is not sufficient. By observing scientists over a period of time, we can generate predictions that take better account of the various dynamic changes in labor markets.

Yoram Weiss

Earnings and Mobility of American Scientists 1960–1970

An analysis of the determinants of earnings and occupational growth of American scientists during the decade 1960–1970 is the objective of this study. We use data on scientists from the

National Science Foundation (NSF) Register of Scientific and Technical Personnel in the fields of chemistry, physics, biology, mathematics, psychology, earth science, agriculture, economics and sociology.

Earnings functions that relate individual earnings to personal and background characteristics are often used to predict the effect of individual choice on future earnings. Typically such estimates are based on a single cross section. There are, however, well known difficulties in applying the results of such comparisons across individuals to the prediction of the earnings of any individual.

One difficulty is that individuals of different ages who are observed at a given point in time probably vary systematically with respect to their date of entry into the labor force. If either the growth rate or the level of earnings depends on the date of entry, cross-section information is not sufficient to separate these vintage effects from the effects of the accumulation of experience on earnings. This difficulty can be overcome by pooling information from successive cross sections.

A second difficulty is that a snapshot at a given point in time provides no information on trends or any other dynamic changes which occur in the economy. The use of cross-section data for prediction is appropriate only in an economy that is either in a stationary or a steady-state equilibrium. Again, by pooling information from several successive cross sections, estimates of trends in earnings can be made.

A third difficulty is that individual earnings are also affected by characteristics that the researcher is unable to observe. The value of longitudinal data is that it enables us to make use of the fact that these unobservables are already to some degree incorporated in the past earnings of the same individual. A standard example is that of unmeasured ability. If the individual can be observed repeatedly, we may incorporate the information on the existence of persistent effects (without actually measuring them) to improve the efficiency of the estimates of the earnings function.

Furthermore, longitudinal data permit us to estimate how much of the individual's "unex-

plained" earnings is persistently observed over his lifetime and how much of his "unexplained" earnings appears to be random from year to year. Clearly, quite different welfare implications are obtained if these "errors" are or are not correlated over time. If uncorrelated, the earnings function's estimate of his lifetime earnings would not be a biased estimate, and individuals with the same observable characteristics could be viewed as having identical "permanent" income. If, however, there is a positive correlation over time, an individual's lifetime income may be systematically below or above the mean of a group with similar observable characteristics.

Longitudinal data may also be useful in eliminating some selection biases which occur when different individuals are sampled. For instance, suppose that the longer the person is in the labor force, the more is learned (say by employers) about the individual's ability. This information is, however, unknown to the researcher. Suppose further that as a result of such learning, individuals may be selected out of the sample (i.e., survival of the fittest); then it is clear that an estimate of experience effects that is based upon comparing different individuals of the same vintage may overestimate the potential gain for any single individual.

We use the longitudinal (ten-year) data from the NSF Registry to estimate earnings functions based upon both cross-sectional and longitudinal information. The major findings of this study with respect to earnings are as follows:

1. Simple cross-section estimates grossly underestimate cohort age-earnings profiles during the period 1960–1970. Furthermore, the growth in earnings is not uniform across experience groups, and more recent vintages tend to have steeper profiles in most scientific fields. Consequently, the rate of return or present value comparisons based on cross sections are likely to be misleading even if the standard adjustment for growth is made.

2. For purposes of estimating mean profiles and mean effects of variables, estimates based on pooled independent cross sections are quite close to those based on longitudinal data.

3. There are important persistent unmeasured individual effects on both the level and

growth of earnings. Consequently, individuals with the same observed characteristics will still have a wide variance in their permanent income.

4. The growth in earnings of scientists is not uniform but tends to vary across fields and by different types of employment (academic, government, and private industry).

A second phase of this study is concerned with the determinants of mobility in rank and mobility into and out of academics, government, and private industry. Again, we study differences among fields, cohorts, and calendar years.

Yoram Weiss
Lee A. Lillard

Dynamic Aspects of Earnings and Income Mobility

Is poverty a transitory status or a permanent condition of individuals and households? How are the chances of entering or leaving poverty related to individual and household characteristics and how sensitive are they to variations in macroeconomic conditions? Is there a high or low degree of mobility over time in an individual's place in the distribution of earnings or a household's place in the distribution of income?

Recently, several economists have used Markov chain models to analyze an individual's transition probabilities among income classes [e.g., McCall's (1973) analysis of poverty turnover] in order to answer such questions. In our view, this methodology is deficient because: (1) Markov chain models inevitably throw away much useful information because income, a continuous variable, is collapsed into a finite number of states (e.g., poverty, nonpoverty); (2) plausible specifications of life cycle earnings functions are inconsistent with the representation of income mobility among a finite number of income classes by a Markov chain at the individual level; (3) unmeasured differences in the determinants of income among individuals imply that the mobility patterns of a group of individuals are not representative of the mobility process followed by any given individual.

In this study, we propose a methodology for the analysis of income and earnings mobility that overcomes these deficiencies. In the case of earnings mobility, it has the added advantage

of providing a direct linkage with traditional human capital earnings functions. The methodology is fairly simple. First, we estimate an earnings function, with, for example, male earnings as the dependent variable, using seven years of earnings data from the Michigan Income Dynamics Panel, 1967–1974. Using modified GLS techniques, we estimate individual permanent, transitory and serially correlated components of earnings due to both measured and unmeasured variables. The link between the estimated earnings function and earnings mobility is then established by using the estimated components to compute the probabilities that an individual's earnings will fall into a particular sequence of discrete earnings classes (e.g., the probability that his earnings will be less than \$3,000 per year for five years). Since these probabilities will be conditional on the individual's personal characteristics (e.g., age, race, education, labor force experience) and macro variables (e.g., county unemployment rate, county welfare payments), we will be able to determine the importance of such factors in accounting for earnings mobility and, especially, for movement into and out of poverty. In addition, we will be able to examine how sensitive the distribution of earnings is to alternative levels of the unemployment rate. After completing our analysis of male earnings mobility, we expect to perform a similar analysis for family income mobility.

Lee A. Lillard
Robert J. Willis

Earnings, Learning, and Consumption over the Life Cycle

This year, I completed research on two closely related papers that connect the literature on human capital accumulation with the literature on life cycle labor supply. In the first paper "A Life Cycle Model of Earnings, Learning, and Consumption," I develop an explicit model of life cycle consumption, hours of work, wage rates, earnings and savings with wage growth endogenous to the model. Nonmarket benefits of education are explicitly incorporated. In contrast with previous work, a rich variety of comparative dynamic results are available so that the model yields predictions for a "typical" consumer as

well as predictions about how age profiles for earnings, consumption and work change in response to variations in interest rates, taxes, inheritances and initial endowments of human capital. One of the most interesting implications of the theoretical analysis is that an increase in income tax rates tends to encourage human capital accumulation.

The consumption function is consistent with the Modigliani-Brumberg model. The theoretical model is estimated using Cobb-Douglas functional forms for one-period utility and human capital production functions. High rates of interest are found that square with previous estimates by Friedman and Landsberger. The Ben-Porath model is adequate to fit the data, but the proposed model is better adapted. Estimates of the rate of depreciation of human capital suggest that previous estimates from income maximizing models tend to overstate the true value for this parameter. This paper appeared in the August 1976 issue of the *Journal of Political Economy*.

A second closely related piece is "The Economics of the Life Cycle." In this article, currently under revision, several models of life cycle labor supply and human capital accumulation are presented. Learning by doing phenomena are incorporated.

James J. Heckman

Leisure, Home Production, and Work

The household production function is by now an established part of economic theory. As formulated by Becker, Lancaster, Muth, and others, the new consumption theory emphasizes the fact that market goods and services are not themselves the agents that carry utility, but are rather inputs in a process that generates commodities (or characteristics) which, in turn, yield utility. A second feature, introduced into the analysis by Becker, is that market goods and services are not the only inputs in this process; the consumer's time is another.

Despite the emphasis on the consumer's non-market time, Becker's general formulation does not make a distinction between the nonmarket time used for work at home and the nonmarket time spent in leisure. Nor has this distinction

been emphasized by subsequent studies which have used the household production function framework. This omission results partly from practical difficulties in distinguishing between the two, given the large number of borderline cases (e.g., is playing with a child leisure or work at home?) and partly because it has not been shown that our understanding of household behavior would be enriched by this distinction.

Past studies and time budget data have convinced me that by overlooking the distinction between consumption time and home-production time, we have been overlooking an important aspect of household behavior and that the introduction of this distinction, though it may create some empirical problems of definition, yields additional insight into consumption patterns and the allocation of household time. Work at home reacts differently to changes in the socioeconomic environment (e.g., the person's education and number of children) than does leisure. The theory in its current form is inadequate to explain these differences.

In my recent work I have tried to reformulate the theory of the allocation of time to allow for this distinction. The model distinguishes between consumption and work time. In contrast to the conventional household production approach, work includes both work in the market and work at home. Work at home is similar in nature to work in the market in that it does not yield direct utility and does not affect directly consumption technology, but is merely a way of securing goods and services which are cheaper to produce at home. Consumption time is the time spent in "producing" commodities and hence a direct source of utility. Thus, one can have somebody else do his work at home, but one cannot get a surrogate to enjoy for him his leisure (i.e., his consumption time). Put differently, work at home is an input in the production of intermediate commodities that are perfect substitutes for market goods. The intermediate commodities are combined with market goods and consumption time to generate the final commodities that enter into the household's utility function. Thus, there exists a clear separation between the production of these intermediate commodities (i.e., home production), the con-

sumption technology (i.e., the combination of market goods, home outputs, and consumption time), and the maximization of welfare (i.e., the choice of the optimum combination of the commodities).

I have completed a first draft of my paper in which I discuss the time budget evidence, describe the model, and examine some of its implications for fertility, child care programs, the demand for domestic service, the gains from marriage, and the evaluation of the output of the home sector. In my future research, I shall apply the model to estimate the production function of home goods.

Reuben Gronau

The Production and Transfer of Wealth within the Family

During my year as an NBER Fellow, I have pursued my study of intrafamily wealth flows and the choice structure that underlies them. More specifically, I have (1) engaged in empirical work on the effects of family background on the schooling, market wage, and husband's income of female offspring; (2) specified theoretically the determinants of consumption shares among family members; (3) analyzed the role of the family (and in particular, the role of the wife) as an informal provider of health and income insurance. Papers on these three topics are currently in draft form.

The empirical analysis of family background variables on female schooling behavior and wealth (market wage, husband's income) uses various cohorts of the National Longitudinal Surveys. The analysis of female schooling suggests that the four background characteristics considered (father's wage rate and schooling, mother's schooling, and number of siblings) strongly influence female schooling attainment in the expected directions (all positive except number of siblings), with a total explanatory power of about 30 percent for middle-aged women. The estimated coefficients do not differ in any dramatic way from comparable estimates for male offspring.

Regressions on husband's income were estimated with female schooling and background characteristics as explanatory variables. The schooling and background variables were found

to have strong and independent effects on the income of the female's husband, with the bulk of background influences being direct rather than through wife's higher schooling attainment. Finally, regressions on female wage rates were estimated with own schooling and family background variables included. The results again had the expected signs, although the coefficient estimates for family background were not consistently significant. Overall, family background variables seem to influence female market wages principally through schooling attainment.

The theoretical paper on consumption shares within the household is devoted to the explicit development of a model of schooling, marriage mate selection, and market work hours. The equilibrium values of female traits in the marriage market are derived in several simple cases, using an approach discussed by Rosen ("Hedonic Prices and Implicit Markets," *Journal of Political Economy*, 1974). The analytics are made complex by the fact that it is necessary to develop a price function for female characteristics if the underlying characteristics are continuous.

My study of the interrelation of health and the allocation of time within the family has both theoretical and empirical aspects. Particular attention is paid to health effects on the joint labor supply of husbands and wives and to the differential labor supply responses to poor health of married and single men. The impact of health on home production hours of the family is also considered. The results are of more than academic interest as they give an indication of how well older individuals and families can economically cope with poor health.

At the theoretical level the concept of a health maintenance function is introduced into a family time allocation model to generate predictions on the time allocation effect of variation in market and health parameters. It is argued that wives can substitute their time for their husband's time in his rehabilitation process, which suggests that married men should devote more time to market activity than single men of equally poor health as long as both demand about the same amount of health investment in total. A number of critical ambiguities arise in the attempt to predict the market behavior of females

when their husbands are in poor health. The wife may withdraw from the market to care for her ill husband or alternatively enter the market to compensate for his lost income, depending on the relative efficiency of her time in each activity. She may even increase time in both activities at the expense of other home activities. Similar ambiguities arise in attempting to predict the effect of wife's schooling on the time allocation decision since it increases health maintenance efficiency as well as market value.

The empirical analysis of the labor supply of older men (ages 45–59) from the National Longitudinal Survey demonstrates the importance of health condition in the choice of annual work hours and the importance of family structure in conditioning that response. An individual in poor health, for example, works on average 1,300 hours less per year than similarly educated (and aged) men in excellent health. The work hours reduction in this case for married men is, however, 450 hours less annually than for men with no spouse present. Considered from a standard 2,000-hour year, the decline in annual hours for nonmarried men in poor health is 84 percent of a full employment year while only 61 percent for married men. Since there is no corresponding fall in the index of health investment by married men (indeed there appears to be a rise), the evidence is consistent with the notion that married men can marshal resources other than their own time to augment their health. This effect is largely independent of the wife's education level.

A simultaneous model of male labor supply and other family income is also estimated on the NLS data to determine the effect of other family income on male labor supply and of male labor supply on other family income. The models suggest that other income does not have a substantial effect on labor supply, but that male labor supply does have a significant effect on other family income. Total other income is estimated to be about \$0.75 higher for each one-hour reduction in work hours of the older male. About two-thirds of this subsidy comes from social welfare sources, one-third from increased earnings of other family members. Other family income increases substantially only in households where the wife has high levels of education.

Finally, time budget data from the Productive Americans Survey are used to trace out more fully health effects on family time decisions. For both husbands and wives, one's own health problems appear to lead to substantial market time withdrawals (about 700 hours and 350 hours, respectively), while home work hours remain unchanged for both. As one might expect, illness of one's spouse leads to quite different time allocation responses for men and women, as men increase their home production time, women their market work time. These work time increases appear to come largely from leisure time in both cases.

Donald O. Parsons

The Covariance Structure of Earnings and the On-the-Job Training Hypothesis

Human capital investment and its returns are basically intertemporal processes. However, most past empirical studies of these processes have been limited to cross-sectional data that provide little or no information on the actual linkage of earnings over time within the individual earnings profiles. In this study a statistical methodology is developed for analyzing cohort time series data on earnings; it is then applied to a simple model designed to illustrate the potential empirical importance of the hypothesis that systematic differences in on-the-job training (OJT) lead to significant differences in individual earnings profiles. The study details the central role played by the covariance structure of earnings when time series data are used to explore these questions. The statistical analysis leads to reasonable upper-bound estimates of the dispersion of the slopes of earnings profiles that indicate empirically relevant systematic differences in the profiles. For a sample of Swedish elementary school graduates, we estimate that the effect of one standard deviation of the distribution of earnings profile slopes applied over a five-year period would create a difference in earnings 24 percent of average earnings at age 26, a substantial effect. These results indicate the substantial stochastic component in earnings. The study also presents some evidence that suggests there is significantly less relative variance in discounted earnings profiles

than in relative earnings for a single year. Both results are consistent with the OJT model.

John C. Hause

Economics of Health

Introduction

The research program in the economics of health 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. Victor Fuchs and Michael Grossman serve as co-program directors. The studies that are reported below focus on two major areas: determinants and consequences of variations in health, and the cost of medical care.

During the past year, Michael Grossman organized a full-scale project on the economics of children's health. The other members of the project are Linda Nasif Edwards, a research associate from Queens College of the City University of New York; Dov Chernichovsky, a visiting scholar from the International Bank for Reconstruction and Development; Douglas Coate, a visiting scholar from Rutgers University; and Fred Goldman, a visiting scholar from Columbia University. The project consists of interrelated studies of production of children's health, demand for their health and medical care services, and interactions among physical health, mental health, and school performance. This research is related to Marcia Kramer's study of abortion and fertility in New York City and to Eugene Lewit's study of infant mortality in New York City, both of which were described in detail in past *Annual Reports*. Kramer and Lewit have completed their empirical work and are writing manuscripts that will detail their main findings. The project on children's health also is related to a study of behavioral determinants of infant mortality in developing economies that was begun recently by Jacob Gesthalter, a pre-doctoral fellow from the City University of New York Graduate School.

Several members of the program are focusing on theoretical and empirical determinants of adults' health. Ann Colle, a senior research analyst, is studying the role of wives' education in

the demand curves for husbands' and wives' health and medical care. Kenneth Warner, a visiting scholar from the University of Michigan, completed a number of papers on the health consequences of technological change in medicine during the past year. Currently, he is investigating the effects of the anti-smoking campaign. Theodore Bergstrom, also of the University of Michigan, recently was appointed a visiting scholar. He plans to work on theoretical issues involved in the valuation of human life.

The program's interest in the high and rising cost of medical care is reflected by studies of the markets for physicians and other health personnel. Victor Fuchs has finished an analysis of trends in earnings of paramedical personnel between 1960 and 1970 and now is examining the responsiveness of hospitals to wage differentials at a given time and to changes in wages relative to the price of nonlabor inputs over time. Edward Hughes, M.D., and Eugene Lewit are concluding their highly successful project on surgical manpower by writing a summary volume. Mark Pauly also is writing a summary volume in connection with his studies of the role of the physician in the supply of and demand for physician and hospital services. Claire Bombardier, M.D. and visiting scholar, is studying variations among physicians in costs generated in the treatment of rheumatoid arthritis. In addition, with Lee Lillard and Kenneth Warner, she is analyzing variations in the roles of income and insurance across specific surgical procedures differentiated by physicians' perceptions of the necessity and efficacy of the procedures.

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

Barry R. Chiswick, "The Demand for Nursing Home Care: An Analysis of the Substitution between Institutional and Non-Institutional Care," *Journal of Human Resources*, forthcoming (available as NBER Working Paper No. 98, July 1975).

Douglas C. Coate, "The Market for Optometric Services in the United States," NBER Working Paper No. 122, February 1976.

_____, "The Production of Health Services in Fee for Service, for Profit Health Practices: The Case of Optometrists," NBER Working Paper No. 115, November 1975.

Victor R. Fuchs, "From Bismarck to Woodcock: The 'Irrational' Pursuit of National Health Insurance," *Journal of Law and Economics*, forthcoming (available as NBER Working Paper No. 120, January 1976).

_____, "Concepts of Health: An Economist's Perspective," *Journal of Medicine and Philosophy*, July 1976.

_____, "The Earnings of Allied Health Personnel—Are Health Workers Underpaid?" *Explorations in Economic Research*, Volume 3, Number 3 (Summer 1976).

Michael Grossman, review of *The Economics of Health Care*, by Seymour E. Harris, *Monthly Labor Review*, Volume 99, Number 4 (April 1976).

_____, "A Survey of Recent Research in Health Economics," *The American Economist*, forthcoming (available as NBER Working Paper No. 129, March 1976).

Michael Grossman and Fred Goldman, "The Demand for Pediatric Care: An Hedonic Approach," NBER Working Paper No. 134, May 1976.

Marcia J. Kramer, "Legal Abortion among New York City Residents: An Analysis According to Socioeconomic and Demographic Characteristics," *Family Planning Perspectives*, Volume 7, Number 3 (May/June 1975).

Mark V. Pauly, "The Role of Demand Creation in the Provision of Health Care Services," presented at the annual meetings of the American Economic Association and the Health Economics Research Organization, Dallas, Texas, December 1975.

Kenneth E. Warner, "A 'Desperation-Reaction' Model of Medical Diffusion," *Health Services Research*, forthcoming.

_____, "Health Maintenance Insurance: Toward an Optimal HMO," 1975 (processed).

_____, "Telemedicine in the Post-Evaluation Era: The Role of Government," presented at the Second Telemedicine Conference, Tucson, Arizona, December 1975.

_____, "Treatment Decision-Making in Catastrophic Illness: A Case Study," 1975 (processed).

Richard N. Watkins, Edward F. X. Hughes, and Eugene M. Lewit, "Time Utilization of a Population of General Surgeons in a Prepaid Group

Practice," NBER Working Paper No. 105, October 1975.

Victor R. Fuchs
Michael Grossman

The Household's Diet Choice and Its Effect on the Health of the Children in the Household

Differences in health levels within the United States are now due primarily to differences in individual decisions about diet, exercise, and lifestyle. The effect of the household's diet choice and food production techniques on the health of the children in the household is the primary focus of our research. The data base for our analysis is the Ten-State Nutrition Survey, 1968–1970, of the Health Services and Mental Health Administration of the U.S. Department of Health, Education and Welfare. This survey contains data for 25,000 households with substantial oversampling of households in the lowest quartile of the income distribution.

Dov Chernichovsky
Douglas Coate

Effects of Wives' Education on Efficiency in Health Production

The primary aim of this project is to examine the effects of wives' education on the demand for health and medical care of both husbands and wives within the framework of the household production function model. An increase in wives' education should result in increases in both her nonmarket productivity and her knowledge of good health practices. Given that wives generally specialize in nonmarket production and that both their time and medical care are significant inputs into the production of husbands' health, wives' education can be expected to have an impact on husbands' demand for health and for medical care.

The data set that I will be using is from the 1970 survey directed by the National Opinion Research Center and the Center for Health Administration Studies of the University of Chicago. The data set contains information on socioeconomic characteristics of husbands and wives and detailed information on their medical care usage. The major portion of my time so far has

been spent on the selection and organization of the data.

Ann D. Colle

The Determinants of Child Health and Development

In a study just getting under way, we propose to examine the determinants of child health, and the interactions among three components of child quality—physical health, mental health, and intellectual development. These two closely related topics will be studied using an exceptionally appropriate data set: Cycle II of the Health Examination Survey. This is a survey of 7,119 children aged 6 to 11 years examined over the 1963 to 1965 period. Besides a complete medical and developmental history of each child provided by a parent, there are data on a host of socioeconomic characteristics of the family and data taken directly from the child's birth certificate and from a school report on the child. Most important, there are results of extensive physical and psychological (including vocabulary and achievement) tests administered by the Public Health Service.

Our first task is to choose appropriate measures of child health from the multitude of physical measures provided. Public health pediatricians are being consulted to guarantee that we examine conditions that are reliable indicators of current health status, as well as conditions that will reflect the extent to which families invest in their children's health (tracer conditions). After choosing appropriate physical health measures, we will utilize recent literature on child quality to derive theoretically and estimate derived demand functions for child physical health. The final step of the study will be to incorporate the other two measures of child quality—mental health and intellectual achievement—in a simultaneous context.

Linda Nasif Edwards
Michael Grossman

Allied Health Manpower

In NBER Working Paper 108, "Are Health Workers Underpaid?" I use the public use samples of the 1960 and 1970 Censuses of Population to

TABLE II-7

Wage Indexes of White Females (Standardized for Age and Schooling), Hospitals and All Nonfarm Industries, by Census Division, 1959 and 1969

| Division | 1959 | | 1969 | | 1969 ÷ 1959 | |
|--------------------|-----------|----------------|-----------|----------------|-------------|----------------|
| | Hospitals | All Industries | Hospitals | All Industries | Hospitals | All Industries |
| New England | .95 | 1.01 | 1.13 | 1.01 | 1.18 | 1.00 |
| Middle Atlantic | .96 | 1.11 | 1.11 | 1.12 | 1.16 | 1.01 |
| East North Central | .94 | 1.07 | 1.03 | 1.04 | 1.10 | .97 |
| West North Central | .82 | .88 | .93 | .91 | 1.13 | 1.03 |
| South Atlantic | .81 | .93 | .98 | .94 | 1.22 | 1.01 |
| East South Central | .76 | .84 | .87 | .86 | 1.15 | 1.02 |
| West South Central | .79 | .87 | .86 | .86 | 1.09 | .99 |
| Mountain | .88 | .89 | .92 | .90 | 1.04 | 1.01 |
| Pacific | 1.00 | 1.07 | 1.09 | 1.06 | 1.09 | .99 |

Note: U.S. nonfarm industries = 100 in each year.

describe the levels and rates of change of earnings in health and to make comparisons with earnings of all nonfarm workers. The study is limited to wage and salary workers with less than 18 years of schooling in order to concentrate on the so-called allied health personnel. The principal findings are as follows.

1. Hourly earnings (standardized for color, age, sex, and schooling) rose about one percent per annum faster in health than in the nonfarm economy as a whole, 1959–1969. The rate of increase was more rapid in hospitals than in other health settings and was more rapid for registered and practical nurses than for other hospital employees.

2. The level of earnings in health in 1959 was substantially below the level in other industries, but by 1969 the difference had mostly disappeared.

3. There were and are substantial geographic differentials in standardized wages of hospital personnel. The pattern of differentials is very similar to that for all nonfarm industries (see Table II-7). Between 1959 and 1969 hospital wages rose more rapidly in the Northeast and Southeast than in the rest of the country.

I am presently concentrating on analyzing the responsiveness of hospitals to wage differentials at a given time and to changes in wages relative to the price of nonlabor inputs over time. In particular, I am trying to explain the dramatic fall in the payroll share of hospital expenditures as shown in Table II-8. This involves estimates of

the elasticity of substitution between labor and nonlabor inputs and estimates of the effects of technological change on factor proportions. It also requires a closer look at changes in hospital accounting practices.

I also prepared a paper on national health insurance (NBER Working Paper 120, "From Bismarck to Woodcock: The 'Irrational' Pursuit of National Health Insurance") that attempts to ex-

TABLE II-8

Payroll as Percentage of All Expenditures, Short-Term General Hospitals, 1959–1974

| Year | Current Prices (in percents) | 1965 Prices* (in percents) |
|------|---------------------------------|-------------------------------|
| 1959 | 62.1 | 66.8 |
| 1960 | 62.3 | 66.1 |
| 1961 | 61.6 | 64.9 |
| 1962 | 61.9 | 64.4 |
| 1963 | 61.7 | 63.6 |
| 1964 | 61.7 | 62.5 |
| 1965 | 61.7 | 61.7 |
| 1966 | 61.1 | 61.6 |
| 1967 | 60.0 | 59.1 |
| 1968 | 59.6 | 57.4 |
| 1969 | 59.1 | 55.9 |
| 1970 | 58.4 | 54.3 |
| 1971 | 58.3 | 52.8 |
| 1972 | 56.8 | 50.2 |
| 1973 | 55.7 | 49.4 |
| 1974 | 54.5 | 49.5 |

* Payroll deflated by an index of hospital wages calculated from American Hospital Association data. Nonpayroll expenditures deflated by the BLS consumer price index for all commodities.

plain the growth of such programs in the face of criticisms that they induce excessive utilization of medical care.

Victor R. Fuchs

Production of Children's Health and Demand for Children's Health and Medical Care Services

The aims of our work are to understand the determinants and consequences of variations in children's health and medical care services. During the past year, we devoted most of our time to a study titled "The Demand for Pediatric Care: An Hedonic Approach." In this study, we argue that differences in quality are a distinguishing feature of the market for physicians' services. Existing studies of the demand for these services have not fully taken account of the implications of such differences. The study has two purposes. The first is to develop a methodology for the estimation of "hedonic" fee functions and demand functions for the quantity and quality of physicians' services. The second is to apply the methodology to analyze the demand for pediatric care (care rendered to children by all physicians) in a sample of New York City residents. In this sample detailed information on physicians' characteristics, such as experience, specialty, board certification status, and membership in professional societies, is combined with data on fees, family characteristics of patients and number of visits. By examining the relationship between fees and physicians' characteristics, we estimate the quality of care received by each child in the sample and the quality-adjusted price paid by his or her parents.

In our theoretical model, we stress the effects of income, the value of time, and the quality-adjusted price of pediatric services on the quantity (visits) and quality of services demanded. Since consumers have the option to trade quality for visits, these effects are somewhat different than those discussed in other studies of the demand for medical care with microdata sets. It is shown that the price of quality relative to the price of visits (the relative price of quality) is directly related to the quality-adjusted price of

a visit and inversely related to the "fixed" costs of a visit. Fixed costs are costs that are independent of quality and are defined as the sum of transportation cost per visit, and travel time to the physician's office and waiting time in the office evaluated at the opportunity cost of the mother's time.

Since the relative price of quality is a positive function of quality-adjusted price, consumers should substitute away from quality and toward visits as quality-adjusted price rises. Although visits need not rise absolutely, the ratio of visits to quality should be positively related to quality-adjusted price. Since the relative price of quality is a negative function of fixed costs of a visit, an increase in these costs would cause consumers to substitute quality for visits. In summary, fixed costs and quality-adjusted price should have opposite signs in the demand curve for quality. In addition, visits should be more sensitive to variations in fixed costs than to variations in quality-adjusted price.

The empirical work in the paper is based on a special sample of New York City residents conducted by the New York City Department of Health in 1965-1966 (the Mindlin-Densen survey). Estimates of quality and quality-adjusted price of pediatric care are obtained from an ordinary least squares regression analysis of the usual fee of pediatric services rendered by primary care physicians in private practice in their offices. These fees were reported by mothers of children in the sample, who also were asked to identify by name all primary care physicians in private practice who examined their children during the survey period. Characteristics of these physicians were obtained from the American Medical Association or New York State Medical Directories.

Differences in characteristics among physicians are assumed to reflect differences in quality or productivity. Therefore, by regressing usual fee on these characteristics, we obtain an estimate of quality from the predicted value of usual fee for a given observation and an estimate of quality-adjusted price from the regression residual. These estimates serve as inputs into the computation of demand functions for visits and quality.

The demand functions are fitted by two-stage

least squares with quality-adjusted price treated as an endogenous variable. This procedure is followed for two reasons. First, we argue that variation in quality-adjusted price in a cross section can be traced in part to imperfect information due to costs of search. Since equilibrium search time should increase and equilibrium quality-adjusted price should decrease as the quantity of pediatric services demanded increases, it would be inappropriate to estimate demand functions by ordinary least squares. Second, our preliminary estimate of quality-adjusted price is likely to contain errors of measurement. By introducing a set of instrumental variables (equivalent to estimation by two-stage least squares), we reduce these errors. In addition to the exogenous variables in the demand functions, the instrumental variables include proxies for search and information.

The major empirical results are as follows:

1. Variations in usual fee associated with physicians' characteristics are consistent with the hypothesis that these characteristics reflect differences in quality. In particular, nonboard certified pediatricians charge higher fees than general practitioners, and board certified pediatricians charge higher fees than nonboard certified pediatricians. Fees are also sensitive to the number of years in which physicians have been in private practice, to the number of memberships in recognized special societies, and to the place of medical education.

2. Quality-adjusted price has a negative and statistically significant regression coefficient in the demand curve for quality. The same variable has an insignificant negative regression coefficient in the demand curve for visits. At the point of means, the absolute value of the elasticity of quality with respect to quality-adjusted price (.08) exceeds the absolute value of the elasticity of visits with respect to quality-adjusted price (.06). This is consistent with our hypothesis that consumers should substitute visits for quality as quality-adjusted price rises.

3. An increase in the fixed costs of a visit simultaneously reduces number of visits and increases quality per visit. In the demand curve for visits, the absolute value of the slope coefficient of fixed costs exceeds that of quality-adjusted price. This same result emerges when

elasticities at the mean are compared. Both results support our prediction that fixed costs should be a more important determinant of visits than quality-adjusted price.

4. The income elasticity of number of visits equals 1.32 at the sample mean. The income elasticity of quality is positive but much smaller, .16 at the mean.

These results have important implications for policies designed to increase the utilization of pediatric services, such as national health insurance and direct cash subsidies to certain groups in the population. Since pediatric visits are very sensitive to income, it might be more efficient to increase these visits by means of direct cash subsidies rather than by means of national health insurance. If national health insurance is adopted, then the form of the insurance might have a significant impact on the quantity-quality mix demanded by consumers. A policy that pays a fixed percentage of the fee of a visit (that is, a policy with a positive coinsurance rate) would lower quality-adjusted price and cause a substitution of quality for visits. A policy that pays a fixed amount of the fee of a visit may be viewed as a policy that reduces the fixed costs of a visit. Therefore, such a policy would cause a substitution toward visits and away from quality.

The relative merits of alternative forms of national health insurance depend in part on the relative effects of quality and visits on health outcomes. Currently, Goldman is using the Mindlin-Densen sample to examine this issue. He also is using the sample to study tradeoffs between private and public pediatric care.

During the coming year, Grossman plans to estimate demand functions for the quantity and quality of pediatric care using the 1970 health interview survey conducted by the National Opinion Research Center and the Center for Health Administration Studies of the University of Chicago. The NORC survey contains the same basic data as the Mindlin-Densen survey for a national sample of the population of the United States. Some advantages of the NORC survey are that it has more detailed information on travel and waiting time, wife's actual or potential hourly wage rate, and the nature of the family's health insurance policy. Grossman also will use this survey to estimate production func-

tions of children's health and demand functions for their health.

Michael Grossman
Fred Goldman

Decision Making in Health and Medical Care

My research has focused on the technology of medicine. Specifically, I have been concerned with how the economically unorthodox environment of medical care influences decision making with respect to the use of given techniques or technologies, and how decision making affects the diffusion of medical innovations.

Since I began working at the Bureau I have completed four papers, three of which concern technological change in medicine. One of these is a prospective consideration of the social and economic factors likely to affect the diffusion of telemedicine; the innovative use of paramedicals and telecommunications technology to deliver medical care to isolated areas (ghettos and rural areas).

In two other papers I discuss findings from a study of the adoption and diffusion of leukemia drug therapies. I selected leukemia drug therapy as a vehicle to examine how the medical profession reacts to the availability of an innovation that both may have the potential to solve a medical problem *and* is easy to adopt (i.e., not constrained by significant capital costs, technical complexity, etc.). In the instance of chemotherapies for the acute leukemias, I discovered an unusual diffusion pattern previously unreported in the literature. My "desperation-reaction" model attempts to explain how the social role of medicine combines with the relatively unconstrained economic environment to produce widespread diffusion during what would be a period of R&D and testing and very limited diffusion in the conventional economic setting. Even for an innovation that ultimately proves to be useful, as a result of "desperation-reaction" diffusion, a temporary period of "negative diffusion"—a partial moratorium—may follow the early enthusiasm for the technique; that was the case here.

The study permitted only tentative conclusions about the role of economic factors in individual treatment decisions, but these led to an

intriguing conjecture, which in turn prompted me to undertake my current research. I discovered that, for the acute leukemias, a patient's economic status was not associated with the decision to administer drug therapy, whereas it was statistically significant in the instance of chronic myelocytic leukemia, a less serious disease for which chemotherapy is generally acknowledged to be ineffective. (In the absence of therapy, the acute leukemias kill their victims within months. Drugs are effective in prolonging life, possibly producing some cures in children afflicted with acute leukemia. Increases in survival time were not associated with the patient's economic status. The chronic leukemias are less virulent, many sufferers lead reasonably normal lives without therapy for several years following diagnosis.) On the basis of this finding I conjectured that an approximation to conventional market behavior may characterize the demand for and provision of medical goods and services that either are not highly effective or that relate to a medical condition that is not considered serious. By contrast, standard market forces often appear to be inoperative when reasonably effective therapies for serious medical problems are involved. (The nonsignificance of economic status in acute leukemia treatment decisions did not simply reflect conventional inelastic demand for therapy. The care of poor patients was often heavily subsidized by a variety of public and private sources.)

This characterization struck a responsive chord in a Stanford physician who guided me to the relevant though largely anecdotal medical literature. I decided to examine the issue systematically. As a consequence, with Claire Bombardier and Lee Lillard, I am beginning a study of variations in the roles of economic factors (income and insurance) across specific surgical procedures differentiated by physicians' perceptions of the necessity and efficacy of the procedures. Our hypothesis is that the lower are physicians' ratings of the underlying condition and the effectiveness of the surgery, *ceteris paribus*, the greater will be the income and insurance elasticities—and hence, implicitly, the role of conventional market forces.

The surgery study reflects my concern with medical decision making. A second project re-

flects my growing interest in the nonmedical determinants of health and in the policy tools available to influence relevant variables. Struck by statements in the press that "... anti-smokers have been wasting their breath" because per capita cigarette smoking is rising, I decided to investigate the effects of the anti-smoking campaign. The relevant issue is not whether or not smoking is on the rise; it is how smoking behavior today differs from what it would have been had there been no campaign against it. Using a methodology like that employed by Sam Peltzman in his study of the effects of automobile safety regulations (*Journal of Political Economy*, Volume 83 Number 4, August 1975), I am fitting time series data for the years prior to the Surgeon General's Report (1964) to a reduced form equation of the determinants of per capita cigarette consumption. Realized values of right-hand side variables since 1964 will then be used in the estimated equation to generate a time path of per capita consumption that might have been expected in the absence of the anti-smoking campaign. This time path will be compared with that actually experienced, the difference providing one indication of the campaign's effects. I am also exploring the possibility of obtaining data on other measures of smoking behavior, such as time series on the number of smokers by sex, and I am considering related cross-sectional analysis.

Kenneth E. Warner

Income, Insurance, and the Incidence of Surgery

The purpose of this project is to estimate income and insurance elasticities for specific surgical procedures. Several researchers have studied price, income, and insurance elasticities of medical care in general. However, aggregated medical services are not a homogenous commodity; and as insurance may have different effects on the demand for different procedures, it is relevant to estimate the effect of economic variables on consumption of specific surgical procedures. One would anticipate, a priori, that the sensitivity to economic variables of "elective" procedures may be higher than for "non-elective" procedures.

Our interest stems from three observations: (1) The first is the evidence from Kenneth Warner's study of leukemia chemotherapy that demonstrates that standard market forces appear to be inoperative for effective therapies involving serious medical problems, while for therapies which are not highly effective or where the medical condition is not considered serious, conventional market forces appear to play a significant role. (2) The second observation concerns the current controversy surrounding the question of "unnecessary" surgery. In a system where most medical care is covered by third-party reimbursement, have we eliminated the role played by economic factors in limiting the expansion of therapies that have not proven effective? (3) The third observation stems from the realization on the part of the medical profession that the expansion of "borderline" therapies may reach a point where the expected benefits from the therapy are smaller than the expected risks. The implication would be that people who are subjected to more borderline therapies are consequently subjected to a greater amount of iatrogenic illness. To the extent that income plays a significant role in the receipt of such therapies, this group may be the affluent.

In the area of surgical care we are gaining a body of empirical evidence that demonstrates wide variations in the incidence of specific surgical procedures; variations which cannot be explained by differences in objective measures of need. A smaller body of empirical evidence suggests a relationship between variations in medical care consumption patterns and economic variables, but such a relationship has not been explored systematically for specific procedures.

Our hypothesis is that the ability-to-pay variables will have more influence on the consumption of surgeries when: the procedure is for cosmetic reasons; the procedure is deemed by physicians to be relatively ineffective; the underlying condition is deemed relatively nonserious. Confirmation or rejection of our hypothesis will be based on differences in the magnitude of effect and significance of income and insurance variables in an analysis of the determinants of surgery, across a variety of surgical procedures

ranked by purpose, necessity, efficacy, and risk.

The primary source of data for the study is the 1963 and 1970 tapes of the National Center for Health Statistics' Health Interview Survey (HIS), a detailed annual survey of the health and medical care of a sample of the U.S. population consisting of roughly 40,000 households (115,000 individuals). 1963 and 1970 were selected because we wish to examine these years individually and then compare experiences from a year predating Medicare and Medicaid (1963) with a year after the establishment of these social programs (1970). A hypothesis is that greater differences in the income distribution of surgeries should be witnessed in the earlier year when many more people were medically and surgically indigent. Also of interest is whether or not Medicare/Medicaid have had differential subsidization effects across types of surgeries.

Claire Bombardier

Lee A. Lillard

Kenneth E. Warner

Doctors and Their Workshops

The purpose of this project is to obtain a better theoretical and empirical understanding of the role of the physician in directing the combination of medical care inputs. Most previous work on the demand and supply of medical services has tended to view different types of care—physicians' visits, hospital use, laboratory tests, prescription drugs—as services that are either unrelated or related only by cross-price effects in the consumer's demand function. This neglects an important aspect: the way in which production and use of all kinds of medical services are directed by the physician in his role of provider of information and manager of the process of care. His behavior, in terms of the prices he charges and the advice he gives, affects more than just the production and use of his own services; it also affects many other important medical care services. Physicians direct the use of hospitals, of laboratory tests, of prescription drugs. These other inputs are generally useful to the consumer only if they are combined with some of the physicians' own time. Of course, the problem of the paid professional expert directing the use of other resources is not unique to

medical care; the relationships of professors to other university inputs and of lawyers to the court system are in many ways similar.

A book-length manuscript incorporating these considerations is presently in preparation. It will include work on physician time as an input into the production of hospital care (described in last year's *Annual Report*), further theoretical development of the model of physician practice, and a theoretical and empirical investigation of the effect of the information the physician provides on the demand for medical care services.

Most of the work this year has been concerned with the last point. While I have no direct measures of the specific content of information, it can be shown that the availability of physicians may, in certain circumstances, serve as proxy for the type of information provided. This has naturally led to a consideration of the so-called "availability effect" in medical care—the empirical finding that, price and other demand variables held constant, use is strongly and positively related to the inputs that produced the care that is used. In a paper prepared for the Allied Social Science Association meetings I developed models of alternative explanations of the availability effect, indicated methods to distinguish among them empirically, and provided some preliminary empirical tests of these methods. In addition to the "information-manipulation" explanation for the availability effect, these alternatives were considered: the availability effect represents differential rationing by the physician on the basis of severity or interest of the patient's condition; the availability effect represents the response of use to a change in the time cost of care; and this effect represents a supply response to omitted demand variables.

Data from the 1970 Health Interview Survey, combined with information from other sources on physicians and hospital beds per capita, are being used. The major empirical finding so far is that, in 22 large metropolitan areas, the number of physician visits is significantly responsive to the number of physicians per capita for persons with little information (proxied by membership in a household in which the head did not graduate from high school) while use is unrelated to availability for persons with much more information (persons in households headed by a

college graduate).

Mark V. Pauly

The Determinants of Variations in Physicians' Behavior

My research has focused primarily on physicians' behavior in medical care utilization. In the medical market the physician plays an unusual role: he is the supplier, but he also influences demand in his role as agent for the consumer. Because of his key role in medical expenditures decision making, a better understanding of the determinants of physicians' behavior could provide valuable policy tools.

In one study I concentrated on the analysis of variations in physicians' behavior while treating patients with similar illnesses. Public attention has been directed recently to the wide variations found in surgical practices, but we have little information on medical specialists' practices. Previous studies have suggested an even wider variation than in surgery, but differences in physician's-patients mix was not accounted for. For the purpose of the study, I have: concentrated on a single illness, rheumatoid arthritis; developed a method to adjust for the severity of the illness; and compared variations in physicians' utilization of medical care inputs under the same reimbursement mechanism and under different reimbursement mechanisms. The first part of the project comparing salaried physicians is now completed. Each medical input (physician visits, drugs, laboratory tests) was weighted according to the fee schedule in 1975 constant dollars and summed over each physician using the visit as the unit of observation. Data were obtained from a university center. I have analyzed 121 patients with rheumatoid arthritis with a total of 1,069 visits from 1969 to 1975; these patients were seen mostly by 12 physicians. Mean cost for a follow-up visit was \$70 and a five-fold variation was observed in physicians' input utilization in treating similar patients. Adjustment for severity of illness with the use of multiple regression analysis reduced the variation to three-fold. Patients' age and sex had no effect, but the coefficient for the insurance coverage variable was significant. A survey was conducted to assess physicians' knowledge of

the cost of the fifteen most commonly ordered tests; half of the physicians overestimated cost and half underestimated. They ranked from 70 percent below to 150 percent above cost. The correlation between physicians' ranking in estimated laboratory cost and their ranking in actual cost was negative, which suggests that physicians who underestimate costs order more tests and those who overestimate costs order fewer. Further, physicians' utilization of medical care inputs declined steadily over a five-year period by almost 50 percent in a clinic with a structured information system and some degree of feedback on performance.

I am now in the process of extending this analysis to compare physicians' input utilization under different reimbursement mechanisms. I will compare salaried physicians with a fee-for-service and a prepaid group practice.

The final project, now in the initial stage, is an attempt to relate variations in physicians' utilization of inputs to possible variations in the quality of the output. The tracer disease will be hypertension which, according to the National Ambulatory Medical Care Survey, ranks fourth in frequency for office visits in the U.S.; further, most are return visits primarily initiated by the physician. I will focus on the variations in frequency of return visits under different financial incentives and how these variations relate to outcome in terms of blood pressure control.

Claire Bombardier

Population and Family Economics

Introduction

Economic aspects of marriage and divorce; interactions between investments in child quality, fertility and intergenerational transfers; and the dynamics of life cycle labor force behavior of married women are three areas that have been emphasized in the research program in population and family economics during the past year. In the first area, Gary S. Becker, Elisabeth L. Landes, and Robert T. Michael have nearly completed a study of marital instability and Landes has been working on a study of the determinants of alimony payments. A synthesis of his previous work on social interactions and the interaction

between fertility and child quality is the subject of Gary Becker's paper with Nigel Tomes titled "Child Endowments and the Quantity and Quality of Children." This paper has been issued as NBER Working Paper No. 123 and appeared in *The Journal of Political Economy*, August 1976. In the third area, James J. Heckman and Robert J. Willis have completed a paper "A Beta-Logistic Model for the Analysis of Sequential Labor Force Participation by Married Women" which was issued as NBER Working Paper No. 112 and will appear in a forthcoming issue of *The Journal of Political Economy*. In the coming year, they expect to investigate life cycle interactions among married women's fertility, labor supply, and market wages using panel data. Also in the coming year, Robert Willis will begin a project on economic aspects of life cycle and family behavior in less developed countries.

The research program in population and family economics is directed by Robert J. Willis. It 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, Department of Health, Education and Welfare. The work on less developed countries will be supported by a sub-contract from the Agency for International Development, U.S. Department of State, and by a grant from the Ford Foundation.

Robert J. Willis

Alimony

I am beginning a study of the determinants of alimony payments in the event of marital dissolution. Marriage and family formation imply investments made by the spouses in "marriage-specific" capital. Women, especially, forego opportunities for acquiring, maintaining, and augmenting labor market skills during the period they are specializing in home production and caring for young children.¹ Alimony can be interpreted as a compensating payment for losses

1. Mincer and Polachek estimate earnings depreciation for women who remain out of the labor market for a period after the birth of their first child to be, on average, 1.5 percent per year. They also find that the depreciation rate varies with educational level, being lowest for women with elementary school education or less and highest for women with at least some college.

incurred by the wife because of time spent in producing home commodities, i.e., consumption and investment commodities which are more valuable within the specific marriage than outside it.

Under this interpretation, length of marriage, number of children, and wife's earning ability are all relevant factors in an efficient determination of alimony. Preliminary empirical results, using a small sample of cases published in the *Annotated Law Reports* indicates that duration of marriage and wife's earnings do affect the amount of lump sum alimony awarded in the event of divorce, holding constant husband's earnings and assets.² I hope to compile a larger, more complete data sample of divorce decrees from published court records in Chicago. With a more complete sample, it should be possible to investigate both the factors affecting whether or not alimony is awarded and the factors affecting the amount, if any, of the award.

Elisabeth L. Landes

Dynamic Labor Supply of Married Women

This year we completed joint research on the dynamics of the labor supply of married women. In this work, we develop statistical techniques that allow us to measure the degree of turnover in the married female labor force. Using panel data from the Michigan study of income dynamics, we find evidence for a *distribution* of participation probabilities in the population at large: holding measurable economic variables constant, some women tend to stay in the labor force for extended periods of time while other women rarely enter. We demonstrate that simple heterogeneity in annual probabilities of participation leads to an apparent state dependence for macro data even when no state dependence characterizes the micro data unit. To estimate the model, we parameterize the beta distribution and demonstrate that the mean probability of participation turns out to be logit. Thus, the specific distribution selected turns out to yield a

2. "Adequacy of Amount of Money Awarded as Permanent Alimony Where Divorce Is or Has Been Granted," 1 ALR 3d 123, and "Excessiveness of Amount of Money Awarded as Permanent Alimony Where Divorce Is or Has Been Awarded," 1 ALR 3d 6.

natural panel extension of the widely used logit model. This research will appear in the October 1976 issue of the *Journal of Political Economy*.

In another line of research, Robert Cotterman and James Heckman are developing life cycle models of labor supply and earnings that explicitly incorporate fixed costs into the analysis. A report on research in progress was given at the Summer Econometric Society meetings.

James J. Heckman
Robert J. Willis

Marital Instability

We are presently completing a theoretical and empirical study of U.S. marital instability. The theory concerns the stability of contracts and is applicable to other contractual arrangements, such as employment tenure.

During the past year we have extended our empirical work to investigate the relationship between the probability of dissolution and specific investments in marriage, measured mainly by the number and ages of children; the propensity to remarry; and the stability of second and higher order marriages. These findings, like the findings for first marriages reported in last year's *Annual Report*, are based on the data from the 1967 Survey of Economic Opportunity (SEO) and the Terman sample of high IQ men and women. Some of our main findings of the past year are the following.

1. Couples who anticipate a relatively high probability of dissolution invest less in marriage-specific capital, such as children, even when dissolution does not materialize. In the Terman sample, for example, a difference of religion between spouses not only increases the rate of dissolution but also reduces fertility even among couples who remained together. Similarly, in the SEO sample the number of children born to white women who remained married was significantly negatively related to an estimate of their probability of marital dissolution in the first five years of their marriage. More explicitly, interracial marriages and those having relatively large discrepancies between the educations of spouses had fewer children.

2. Divorced men and women are more likely to remarry the longer the duration of their

first marriage. This suggests that divorced persons with greater gains from marriage are more likely to remarry because they tend to divorce later than persons with smaller gains. There are about 7 percentage-point differences in remarriage rates between divorced men and women for a given period of exposure to the remarriage market. This difference appears to be entirely explained by the negative effect of children on a divorced mother's likelihood of remarriage.

3. Second and higher order marriages are more likely to dissolve than first marriages when the first marriage ended by divorce (but not when it ended by death of a spouse). Children from first marriages appear to increase the likelihood that a woman's later marriages will dissolve, which suggests that children in one marriage become negative specific capital in a subsequent marriage.

We expect to submit the paper for publication in the fall of 1976.

Gary S. Becker
Elisabeth L. Landes
Robert T. Michael

Taxation; Social Insurance

During this past year, the Center established a new program area in the economics of taxation and social insurance. Work in the taxation area is funded by a grant from the United States Treasury Department. I have completed two papers and am in the process of preparing several others. Martin Feldstein and Joseph Stiglitz are also preparing a paper as a part of this research effort, and in January the Center hosted a small conference on current research in taxation. In the area of social insurance, I am planning a program that will involve several researchers.

My paper "Notes on the Tax Treatment of Human Capital" (NBER Working Paper No. 116), will appear in the U.S. Treasury's *Conference on Tax Policy*. In this paper, I detail the many ways in which the tax system affects both total investment and the composition of investment between human and nonhuman capital; it also presents analytical models of tax incidence in an economy with human investment and optimal

taxation under constraints on the taxation of human capital.

In a second paper on taxation "Taxation, Saving, and the Rate of Interest," I have estimated the effect of tax-induced decreases in the real net rate of return on private saving, income distribution, and welfare. Using a variety of measures for the real net rate of return on capital, functional forms, estimation methods, and sample periods, I conclude that the interest elasticity of the saving rate (for real, net interest) is approximately 0.3; much larger than the figure found in most previous studies. This finding has certain implications regarding the way taxation policies affect income distribution and welfare: (1) the tax-induced distortion in the timing of consumption amounts to a dead-weight loss of over \$50 billion annually; (2) a large fraction of taxes on income from capital is shifted to labor in the long run; (3) previous empirical estimates of tax burdens across the functional and personal income distributions greatly exaggerate the progressivity of the income tax and the alleged regressivity of consumption taxes.

Among the papers in progress in the taxation area are several on the taxation of human resources. Eytan Sheshinski and I are currently

working on a variety of issues in the tax treatment of the family and the tax treatment of physical versus human capital. Martin Feldstein and Joseph Stiglitz are working on a model of taxation and wealth transfers at death.

In the social insurance area, I have completed a paper entitled "Social Security and Retirement Decisions" (NBER Working Paper No. 107), which will appear this year in *Economic Inquiry*. This study uses data from the first five years of the University of Michigan's Panel Study of Income Dynamics to follow the retirement patterns of a cohort of elderly white males. The results suggest that both the income guarantee and the earnings test in the social security program have substantial effects on the probability of retirement. These estimates successfully predict the time series decline in the labor force participation of the elderly.

We plan to develop a coordinated research effort in social insurance over the next year or two. Several topics will be addressed, including the effects of old age, disability, and unemployment insurance programs on household decision making and on the aggregate economy.

Michael J. Boskin

4. FINANCIAL AND INDUSTRIAL INSTITUTIONS AND PROCESSES

Financial Institutions and Processes

Introduction

The National Bureau's program of research in finance has typically concentrated on changes in financial institutions, instruments, and techniques as this sector responds to the shifting economic and legal environment. The closely related area of monetary research is reported on above under Business Cycles.

The major new program in the financial area is the study of risks and capital adequacy, projected in last year's *Annual Report* and now financed by a grant from the National Science Foundation's division of Research Applied to National Needs (RANN). Several staff members have been appointed and the study will be running at full scale in the coming year.

A continuing study is that on individual investor portfolio performance, directed by Wilbur Lewellen. The researchers involved exploit a unique sample of holdings and transactions in brokerage-house accounts and related information about the investors to follow the performance, the strategy, and the characteristics of this little-understood segment of financial markets. In view of the strong current interest in the functioning of capital markets we are planning to bring the record of these accounts up to date and expand the study in other directions. Also reported on below is the cooperative enterprise with university groups on financial flows and economic activity in the United States.

The program of studies on the effects of inflation on financial markets, our major effort in the last few years, is mainly in the stage of revision of manuscripts and in the publication

process as reported by Phillip Cagan, below. Also published recently, in the Summer 1975 issue of *Explorations in Economic Research*, Vol. 2, No. 3, was the report of the Symposium on "Regional Stock Exchanges in a Central Market System," of which Donald Farrar was the chairman.

Robert E. Lipsey

Risks and Capital Adequacy

Last year's proposals concerning the problems of improving information flows about financial institutions has led to a grant from the National Science Foundation to NBER to perform research on problems related to measurement of risks and capital adequacy in financial institutions. Specifically, we are developing procedures to estimate the portfolio risk that individual financial institutions assume as a result of the composition of their assets and liabilities by type, industries, maturities, and other forms of concentration. We are also examining related problems, such as proposals for utilizing more fully increased public information and the market for deposits and securities in evaluating risks and capital adequacy, as well as estimates of the private and social costs of different levels of firm capital. The measurement of risks and their modeling will be based upon portfolio theory and on empirical examination of how the returns (both positive and negative) of individual activities have varied in the past and are likely to vary in the future.

Risks depend upon the specific distributions of an institution's assets and liabilities and upon losses or gains that may occur in each category as a result of outside events, such as recession, interest rate movements, exchange depreciation, exchange controls, local disasters, and sharp changes in liabilities. The measurement of risks is being made through studies of how the market has reacted to institutions with different types of activities; how the values of securities have altered with movements in interest rates and their term structure; how economic results in specific industries have changed as the result of past events; how problems of concentration arise; as well as on the experience of individual institutions.

In addition to measuring risks, we are analyzing methods of reducing risks through changing portfolios or through altering the level of capital in relationship to other activities. As part of this analysis we will perform a detailed analysis of how changes in the level of capital are expected to influence both the private and social costs of institutions and how these may be held to a minimum.

Sherman Maisel
Paul Cootner
David Lane
Jay Morrison
David Pyle
Barr Rosenberg
William Sharpe

Individual Investor Portfolio Performance

The continuing concern with 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 those entities. On the other hand, there are virtually no hard data on the corresponding activities of the individual investor who manages his or her own portfolio. Our study seeks to fill that vacuum by examining the investment history of a large sample of such individuals over a twelve-year period ending with December 1975. 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. Preliminary findings were reported on in a paper entitled "The Individual Investor: Attributes and Attitudes," which appeared in the *Journal of Finance* (May 1974). An examination of the cross-sectional profile of individual asset portfolios was published in the *Journal of Finance* (May 1975), 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. A paper labeled "Patterns of Investment Strategy and Behavior

Among Individual Investors" has been accepted for publication in 1976 by the *Journal of Business*. The linkages between investors' demographic circumstances and their investment policies are examined, as well as the inter-relationships among the various elements of such policies. The findings suggest distinct differences in behavior which are manifest throughout the range of strategy components. That evidence has been extended to address the question of its implications for possible segmentation in the securities markets. The results are contained in a manuscript due for publication in the *Financial Analysts Journal* in 1976; the title is "Market Segmentation: Evidence on the Individual Investor." Indications of the specialization by investor subsets in particular security types and market locales are revealed.

Data on the investment performance of the sample are analyzed in a manuscript "Realized Rates of Return on Common Stock Investments: The Experience of Individual Investors." From the account transactions records described above, the returns attained on some 75,000 "round trips" in equity securities between 1964 and 1970 have been computed. Those returns are compared with the results of investing instead in a diversified portfolio of equivalent-risk equity securities for matching intervals. Evidence of some skill in security selection by the sample emerges, that phenomenon being most apparent within relatively short investment round trip cycles. The paper has been submitted for publication, as has a manuscript entitled "Stock Exchange Listings and Securities Returns," in which the impact of becoming listed on the NYSE or ASE on common stock price movements is detailed. The securities price data base compiled for the analysis of investor portfolio performance provided the necessary raw material. The conclusion is that listing does appear to confer some valuation benefits, and the evidence is tested for its implications for market efficiency. I have recently completed a paper on an empirical analysis of brokerage house securities recommendations in which I treat the matter of the quality of professional investment counsel, concentrating on the recommendations of the cooperating brokerage house during the period 1964 through 1970. Some 6,000 research

reports are examined. I find that investors could, in fact, have profited by following the advice proffered, although the net gains would have been relatively modest in comparison with general market opportunities.

Presently, the relationships between portfolio and transactions characteristics and investment success or failure are being explored through the use of both the round-trip data file and the reconstructed total portfolio positions of the sample as of the end of each month from January 1964 to December 1970. The process of updating these figures through the end of 1975 has also begun. An examination of the characteristics of those investors who "withdrew" from active participation in the equity market over the interval considered is partially completed and the design of a study of the impact of tax policies on investor trading patterns, investment returns, and securities choices is in process. These should be completed by late 1976.

The project is being partially funded by grants from the Investment Company Institute and the cooperating brokerage house.

Wilbur G. Lewellen

The Effects of Inflation on Financial Markets

Several papers in this study, supported by a grant from the American Council of Life Insurance, are being published during 1976. One by Thomas Sargent, "Interest Rates and Expected Inflation: A Selective Summary of Recent Research," was published in *Explorations in Economic Research* (Summer 1976). Papers by Lintner, Piper, and Fortune from their study of financial institutions are noted below, as well as their continuing work on inflation and security prices. A list of previously published papers was given in last year's *Annual Report*.

Phillip Cagan

Investment Policies of Major Financial Institutions Under Inflationary Conditions

The study of the use of income participations by major life insurance companies, savings banks, and other institutional investors has been completed and is scheduled for early publication in *Explorations in Economic Research*. Final revi-

sions are being made in the related study of the use of equity kickers such as warrants and convertible features on lending in the private placement market, before it is submitted for Board approval. Our long 250 page manuscript on "Forward Commitments in Bonds and Mortgages" has also been reviewed by the staff and is being revised. In view of its length, the substantial theoretical section will be published as one paper to be followed by the descriptive material and empirical analysis in a separate article.

Another paper, on the lognormality of security returns and its implications for portfolio selection and market equilibrium, has also now been reviewed and a revised version will soon be submitted to the Board of Directors.

Our work on the impact of inflation on corporate profits and security returns is continuing. Over the last year, further work has been done on the measurement of differences between historical and replacement cost depreciation and the relation between fully adjusted economic profits and capital requirements under conditions of varying and uncertain rates of inflation. The portfolio implications of this work are also being developed.

John Lintner
Thomas Piper
Peter Fortune

Financial Flows and Economic Activity in the United States

Although the importance and complexity of interactions between the financial and real sectors have long been recognized, it is only in recent years that these processes have been subjected to intensive scrutiny and empirical analysis incorporating extensive detail on portfolio allocations and financial accounts, interindustry flows, expenditure decisions, and the foreign sector. The National Bureau and Yale University, with the support of the National Science Foundation, are pursuing this objective with complementary efforts at the University of Pennsylvania and other research centers. Proposals have been submitted for continuing support and expansion of this research so as to provide more powerful analytical tools for the examination of structural effects and policy alternatives in short- and

long-run movements of the economy.

In this phase, we are working to eliminate the traditional analytical separation between expenditure and financial decisions. This will permit the examination of impacts of financial structure and regulations, funds rationing, disequilibria in financial markets and in business and household asset-liability portfolios, and other phenomena little studied to date, as well as the more standard macroeconomic consequences of monetary and fiscal policy.

Our analysis is disaggregated both for financial behavior and for production. It provides detail on 24 producing sectors within a stage-of-processing framework that allows tracking of the cascade of orders from final demand to primary processing and of shipments and value added from primary processing to final expenditures. Combining this information with financial and capital accounts for these same sectors, together with that on labor market conditions, allows for the evaluation of monetary and fiscal policy impacts on the adequacy of production capacity (that is, the examination of potential bottlenecks), a key issue in questions of capital shortages now being debated.

A paper surveying estimates of capital requirements for this period 1975-1985 has been prepared and submitted for publication. Also, at the request of the Joint Economic Committee, a review of U.S. long-term growth prospects over the next decade is being conducted. Other papers detailing underlying theory of financial real sector interactions are in preparation.

Gary Fromm

Industrial Institutions and Processes

Concentration and Profit Rates

This study, financed in part by the Educational Foundation of the American Association of Advertising Agencies, is near completion with the publication of the paper "Concentration and Profit Rates: New Evidence on an Old Issue" (co-authored by Rao Singamsetti), published in *Explorations in Economic Research* (Winter 1976). Some experimental work, however, is continuing to determine the feasibility of a study

to explain the length of time it takes for a firm's profit rate to return to equilibrium, given an initial force that propels it away from an equilibrium.

Michael Gort

Diffusion of Product Innovations

This study was financed by the National Science Foundation. It is currently in the manuscript preparation stage. One paper, entitled "Time Paths in the Diffusion of Product Innovations," was presented at the March 1976 joint meeting of the Institute of Management Science and the Operations Research Society of America. In the study I decompose, into five stages, variations in entry rates of firms into the production of basically new products. The statistical data used relate twenty-four product innovations.

A second paper entitled "The Effect of Entry, Market Growth, and Innovations on Innovations," is currently in preparation. In it I focus on the determinants of changes in the rate of process and product modification innovations over the life histories of new products. Stephen Klepper is collaborating with me on both papers. The study is scheduled for completion this summer.

Michael Gort

Marketing and Advertising Studies

A manuscript entitled "The Effects of Advertising on Intra-industry Shifts in Demand" has been completed during the past year and submitted to the staff for review. This is a companion piece to my earlier study analyzing the inter-industry effects of advertising on demand that appeared in the Spring 1976 issue of *Explorations in Economic Research*.

In the new study, the impacts of advertising on market shares are examined in five nondurable industries: cigarettes, softdrinks, cereals, beer, and gasoline. Several models employing the Nerlove-Arrow formulation of advertising as a capital good were specified and tested. The empirical analysis suggests a significant effect of advertising on market shares, for both current and future periods, in all industry classes except gasoline. In addition, in three of the industries—cigarettes, softdrinks and cereals—calculated

optimal advertising to sales ratios are in close accord with actual values, lending further credence to the observed results in these industries.

A particularly interesting finding of a methodological character emerging from this study is the large disparity in estimates on the lagged effects of advertising associated with two different estimation techniques. Specifically, the Koyck transformation method, the most frequently used approach in past work, indicated an average depreciation rate on advertising capital of only 17 percent. On the other hand, a nonlinear conditional regression approach for estimating the same structural model indicated a much faster average depreciation rate of 47 percent. Given that the latter method should provide superior estimates on econometric grounds, some reanalysis of advertising lagged effects for other industry samples along these lines would seem desirable.

The results of this paper, taken in conjunction with my earlier study of the inter-industry effects of advertising on demand, suggest that the primary impacts of advertising are on consumer's choice of brands or products within a particular industry class rather than on budget allocations across product classes.

The study is financed in part by the Educational Foundation of the American Association of Advertising Agencies.

Henry G. Grabowski

The Effects of Product Quality Regulation on Innovation: The Case of the U.S. Pharmaceutical Industry

Three papers have been completed during the past year. The first paper "Structural Effects of Regulation on Innovation in the Ethical Drug Industry," by Henry Grabowski and John Vernon, will be published in a book of essays in honor of Joe Bain by Ballinger Press. In this paper the authors examine the concentration of innovation over time in the ethical drug industry, as well as the relationship between size of firm and innovative output. By comparing trends in the U.S. with trends in the U.K., we find that increased regulation in the U.S. since 1962 (when the Kefauver Amendments to the 1938 Food, Drug, and Cosmetic Act were passed) is a likely cause

of the increased concentration of innovative output in the U.S.

The second paper "Regulation and Innovative Activity in the Pharmaceutical Industry" by Henry Grabowski, is a monograph being prepared for publication by the American Enterprise Institute. It is essentially a synthesis of the literature and review of possible policy reforms.

The third paper "The Effects of Regulatory Policy on the Incentives to Innovate: An International Comparative Analysis," by Henry Grabowski, John Vernon, and Lacy Thomas, was completed in December 1975 and presented to the American University Conference on the Impact of Public Policy on Drug Innovation and Pricing in Washington, D.C. In this paper we attempt to untangle the effects on drug innovation of regulatory and nonregulatory factors through a comparative international analysis of the U.S. and the U.K. over the pre- and post-amendment periods. We estimate a production function model of new product innovation for this industry similar to Martin Baily's model in the *Journal of Political Economy* (January/February 1972). However, instead of trying to measure research depletion through a moving average of past introductions (as Baily did), we attempt to separate regulatory from nonregulatory factors through a comparative analysis of developments in the U.S. and U.K.

The dependent variable in Baily's model is in effect a productivity measure—the number of new chemical entities (of industry origin) introduced annually in the U.S. per dollar of R&D outlay by the industry. We were able to develop a comparable variable for the U.K. over the period 1960 to 1970. Our formal analysis is based on the premise that any depletion of research opportunities would influence the productivity of R&D in both countries in a similar manner. However, any negative effects of regulation would show up as an additional observed effect in the U.S. but not in the U.K.

As discussed in the paper, international comparative analyses are subject in general to some downward bias in isolating the impacts of regulation on innovation. This is because any adverse impacts on innovation resulting from increased regulation in the U.S. will have some tendency to spill over to other countries and

result in lower introductions abroad as well. However, this source of downward bias is minimized in our analysis by the fact that the dependent variable is a R&D productivity measure rather than the absolute level of introductions. Regulatory changes in one country can be expected to have much less impact on shifts in the R&D production function in other countries than on their absolute level of introductions. Thus, while our analysis tends to understate the effects of regulation on innovation (for other reasons as well), the bias is minimized by our use of R&D productivity as the dependent variable.

A principal finding of our analysis is that U.S. R&D "productivity" declined by about six-fold between 1960–1961 and 1966–1970. The corresponding decrease in the U.K. was about three-fold. Clearly, some worldwide phenomenon, which might be labelled a "depletion of research opportunities" but which undoubtedly encompasses other factors as well, seems to hold for pharmaceutical R&D. However, there is also strong support for the hypothesis that an additional factor is at work in the U.S. industry.

Given the much more rapid decline in U.S. productivity, it is difficult to avoid the conclusion that there has been a significant effect on innovation as a result of the 1962 Amendments. On the basis of a more sophisticated econometric analysis using these results, we further estimate that the 1962 Amendments have roughly doubled in the cost of a new chemical entity. This estimate is actually quite close to that from Martin Baily's earlier study. However, the depletion measure used in the original Baily model proved to be quite unstable when his analysis was extended forward in time and this was a primary factor motivating our comparative analysis of international data on R&D productivity.

Support for this work has been provided by the National Science Foundation.

Henry G. Grabowski
John M. Vernon

Industrial Demand for Energy

In this research the Census of Manufactures data are used to examine the characteristics of industrial demand for electric energy, fuel oil, natural gas, and coal. Results of the study will

include estimates for each two-digit industry of all own and cross price elasticities of demand and partial elasticities of substitution. The effects of technical change on the utilization of energy inputs will also be examined.

Complete systems of energy demand equations are derived from flexible cost functions that impose minimal a priori restrictions on the estimated elasticities. The systems of demand equations will be estimated with data for 1974, 1971, 1962, and 1958. The 1958 results will include estimated demand equations for capital and labor as well as energy inputs and will provide tests of the separability of energy from other inputs. The 1958 results will also provide information on returns to scale in each industry.

Preliminary results of this research were presented at the Winter Meetings of the Econometric Society in December 1975. The results indicate that industrial demand for energy is significantly price responsive. The degree of responsiveness is greatest for fuel oil and least for electric energy. The research is supported by a grant from NSF-RANN.

Robert Halvorsen

International Comparisons of Industrial Concentration in Latin America

This study provides a complete and thorough empirical picture of the level of industrial concentration in the Latin American manufacturing sector. In this respect, several indicators of industrial concentration have been computed, i.e., the Herfindahl index, entropy measurements, Gini coefficient, and Niehans index. These indicators have been computed at the three-digit ISIC (International Standard Industrial Classification) for the following ten Latin American countries: Argentina, Chile, Colombia, Costa Rica, Ecuador, Mexico, Paraguay, Peru, Uruguay, and Venezuela. The Census of Manufactures data for each country during the 1960's were used.

Furthermore, an analysis of the industrial concentration values provides the following conclusions:

1. There exists a similar pattern of industrial concentration in the Latin American countries. For example, industries which have higher

levels of concentration in one country coincide with those which have higher levels in other Latin American countries. The industries with the highest levels of concentration are: tobacco, rubber, basic metals, and the manufacture of paper.

2. Latin American countries which have a smaller market size have systematically higher levels of industrial concentration than those Latin American countries which have a larger market size.

This paper is written in Spanish and has been submitted for publication in the journal *Ensayos ECIEL*.

The research was done at the Economics Department of the Catholic University of Chile by S. Leniz, C. Swinburn, and me. The conclusions section was written, editing was completed, and general revisions made during my stay at the National Bureau, which was financed by the Rockefeller Foundation's research fellowship grant.

Patricio Meller

Efficiency Frontiers for Industrial Establishments of Different Sizes

This paper is a revision of chapter 4 of my Ph.D. dissertation "Production Functions and Efficiency Frontiers for Industrial Establishments of Different Sizes: The Chilean Case, Year 1967," University of California, Berkeley, January 1975. In it I examine the technical efficiency of different types of establishments in twenty-one Chilean industries, and offer empirical evidence for the coexistence of firms with varying efficiency levels. A separate analysis is made for each industry, relating levels of technical efficiency to establishment size and such other indicators of modern technology as capital-labor ratios and white collar-blue collar ratios.

The study is based on data from the Chilean Industrial Manufacturing Census of 1967, disaggregated at the establishment level (11,468 establishments employing five or more persons). Since the twenty-one industries, at the four digit ISIC (International Standard Industrial Classification) level, account for 69.9 percent of all industrial establishments, it may be assumed that the results obtained have general

validity for Chile's industry.

These results can be summarized as follows.

1. Approximately 75 percent of the industrial establishments have a level of technical efficiency more than 50 percent below that of the most efficient establishments in their particular industry.

2. Large establishments are not necessarily more efficient than smaller ones in the same industry, nor is large size a prerequisite for efficiency. However, there is less dispersion in efficiency among large establishments than

among small ones.

3. Establishments using supposedly modern techniques have neither higher nor lower technical efficiency than those with supposedly old-fashioned techniques.

This paper was published in *Explorations in Economic Research*, Volume 3, Number 3 (Summer 1976).

Financial support for this article was provided by the Rockefeller Foundation within its fellowship grant for my stay at the National Bureau.

Patricio Meller

5. INTERNATIONAL STUDIES

Introduction

In keeping with the increasing importance of international economic relations to the United States, the international program has grown greatly since its inception fifteen years ago when Hal Lary joined the staff of the National Bureau as the program director. It is now one of the largest areas of Bureau activity, including several research projects, an international exchange program, a fellowship program, and a conference series, the latter two of which are described elsewhere in reports by Douglas Eldridge and M. Ishaq Nadiri. The international studies involve not only a focus on international problems, but also the active participation of scholars from other countries and cooperation with foreign research institutions.

The only completely new studies begun this year are those on trade adjustments in less developed countries to exchange rate changes, by Romeo Bautista, and the growth and structure of labor absorptive capacity in Latin American manufacturing industries, by Patricio Meller and M. Ishaq Nadiri. Both Bautista and Meller hold Bureau fellowships for foreign scholars. The results should provide some valuable comparisons with those for developed countries that will emerge from the Kravis-Lipsey research on price-quantity relations in U.S. trade and with the findings of Anne Krueger's project mentioned below. Also related to the Bautista and Kravis-Lipsey research is Phillip Cagan's study of foreign influences on input costs and manufacturing prices, discussed above in the section on prices and productivity.

Anne Krueger's study of Alternative Trade Strategies and Employment, now fully staffed, will probably be the largest single project among those reported below for the coming year. Other active studies include those on multinational firms, international price developments, and the U.S.-U.S.S.R. Scientific and Technical Program of Cooperation.

Several programs are now in the publication stage. Nine country volumes have been published from the Bhagwati-Krueger study of foreign-trade regimes and economic development and the two synthesis volumes will soon be ready for Board review. George Garvy's volume "Money, Financial Flows, and Credit in the Soviet Union" is in press. Some of the papers from the Conference on Trade, Finance, and Development among Pacific Basin Countries were published as one issue of *Explorations in Economic Research* (Spring 1976).

The major new work planned for the international area is an expansion into financial and monetary aspects. We hope to begin research this coming year on an examination of the international transmission of inflation through the world monetary system, in which Michael Darby and Anna J. Schwartz would be joined by two associates. There would be obvious gains from their interchange with others engaged in the Bureau's long series of monetary studies as well as the Cagan and Kravis-Lipsey studies mentioned earlier. Another part of our plans is to initiate work on financial aspects of the operations of multinational firms.

Robert E. Lipsey

Alternative Trade Strategies and Employment

During the past year, personnel to participate in the project were selected, papers sketching out the theory underlying the project and outlining various aspects of the methodology to be used in the country studies were prepared, and two working parties of project participants were held.

The countries being studied, and individuals who have undertaken country studies, are as follows:

Brazil:

Jose Carvalho, Vargas Foundation

Chile:

Vittorio Corbo, Concordia University

Patricio Meller, Corporacion de

Investigaciones Económicas para
Latinoamérica

Colombia:

Francisco Thoumi, George Washington

University

India:

T. N. Srinivasan, Indian Statistical Institute

Indonesia:

Mark Pitt, University of Minnesota

Ivory Coast:

Terry Monson, Illinois State University

Jacques Pegatienan, Centre Ivoirien de
Recherches Economiques et Sociales

Kenya:

Peter Hopcraft, University of Nairobi

Leopold Mureithi, University of Nairobi

Pakistan:

Stephen Guisinger, University of Texas at

Dallas

Tunisia:

Mondher Gargouri, University of Tunis

Mustapha Nabli, University of Tunis

Uruguay:

Alberto Bensi6n, University of Uruguay

Anne O. Krueger, Project Working Paper
No. 1 "Plan of Research for Country Studies"

James M. Henderson, Project Working
Paper No. 2 "Data Requirements and Rectifica-
tion Procedures"

James M. Henderson, Project Working
Paper No. 3 "Programming Models of Optimal
Production and Trade"

Jere Behrman, Project Working Paper No. 4
"Data Requirements for Statistical Exploration
of Production Relations"

T. Paul Schultz, Working Paper No. 6 "In-
vestigating Distortions in the Labor Market: Data
Requirements and Methods."

The first paper details part of the theory of the trade-employment relation, in the context of the Heckscher-Ohlin model, with many commodities, three factors and n countries. Project Working Papers Nos. 1 and 2 set forth the procedures to be used to obtain basic data for the country studies. Project Working Paper No. 3 describes the model James M. Henderson of the University of Minnesota will use in his special study aimed at identifying comparative advantage. Project Working Paper No. 4 describes the work Jere Behrman of the University of Pennsylvania will undertake in his special study in which he attempts to identify the scope for substitution in various traded goods industries.

Project Working Paper No. 6 outlines the analysis T. Paul Schultz of Yale University is doing of labor markets in developing countries and their impact on the trade-employment relationship. Still another special study is being carried out by Robert Lipsey of the NBER, who will investigate the factor proportions used by multinational firms and how they differ in various countries.

The first working party of project participants was held at the National Bureau's New York office on December 8 to 10, 1975. There was discussion of each participant's plans and the problems being encountered and ways of meeting them.

The second working party, held at Bear Mountain State Park on August 30 to September 3, 1976, was devoted to a review of completed parts of the studies and to plans for the work

In addition, studies on South Korea, Taiwan and Thailand are being undertaken under the sponsorship of the Center for Asian Manpower Studies.

The following papers have been prepared:

Anne O. Krueger, "Growth, Distortions, and Patterns of Trade among Many Countries"

still to be done.

This project is being carried out under a research contract with the Agency for International Development.

Anne O. Krueger

Studies of Multinational Firms

The main element in these studies for the past year has been the study of the impact of multinational firms on technology and trade flows described in the next report. It is one of a series of projects related to a data base on individual firms collected in several earlier and concurrent National Bureau studies. As that study nears completion our work in the next year will focus on two topics. One is the factors determining the location of overseas manufacturing operations of U.S. firms, under a contract with the U.S. Departments of Labor and the Treasury. The second is factor substitution, particularly the use of capital and labor, in U.S. owned manufacturing plants in less developed countries, as part of Anne Krueger's study of alternative trade strategies and employment. In addition we hope to begin a study on the relations between domestic and foreign investment of individual firms.

The data base for these studies 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 data on the domestic and foreign operations of U.S. based firms collected by the National Bureau. The Commerce Department data are, of course, confidential, and we do not have access to them except in the sense that the Department has performed computations on them, and on combinations of their data with ours, which have been used in some of our studies. The Commerce Department data are part of our data base only in the sense that we have matched National Bureau company identifications to those of the Commerce Department and can therefore use those data in combination with our own.

The National Bureau's data collection 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, and was continued under a later grant by the Ford Foundation and under the study of the impact of multinational firms on technology and trade flows. It is also being expanded by the work on a microdata set for enterprises, reported on above as part of the program on the measurement of economic and social performance. Included are financial data for more than 2,500 corporations; their identification as foreign investors or non-investors; a breakdown of domestic employment for about 1,300 firms in 1970 and 1,500 firms in 1972, by four-digit industry and, for 1972, by location within the United States, and similar distributions for several hundred firms for 1960 and 1965. Also part of the National Bureau's data collection is information, collected through questionnaires and from public sources, for about 6,000 affiliates of 300 companies on the age, location, main industry, and main products of each affiliate. Within the next year we hope to add information on the occupational distribution and other characteristics of each company's employment in the United States.

Although the literature on multinational firms has grown enormously since we first began the assembling of these data, the materials for quantitative analysis have remained meager, and much of the discussion is speculative or polemical. We are operating in the belief that most of the important questions raised about the operations of these firms still await serious empirical research and that since the growth of multinationals is related to the special characteristics and comparative advantages of each such firm, the best method of studying them is at the individual firm level.

Robert E. Lipsey

The Impact of Multinational Firms on Technology and Trade Flows

This project, which was financed by a grant from the Research and Development Assessment Division of the National Science Foundation, is now nearing completion. Its purpose was to examine several aspects of the transfer of technology by U.S. based multinational firms, including the nature of the firms' comparative

advantage, the forms and characteristics of their technology transfers and their overseas operations, and the impact of these on U.S. trade and on the competitive position of U.S. companies. Both broad studies across all manufacturing industries and case studies of a few individual industries were part of the program.

The papers completed so far, for which the research was partly or completely financed from this grant, are as follows:

"Multinational Firms and the Factor Intensity of Trade," by Robert E. Lipsey and Merle Yahr Weiss, NBER Working Paper 8, September 1973 (to be revised).

"Exports and Foreign Investment in the Pharmaceutical Industry," by Robert E. Lipsey and Merle Yahr Weiss, NBER Working Paper 87, revised version, January 1976.

"Innovation and Foreign Investment Behavior in the U.S. Pharmaceutical Industry," by Benjamin I. Cohen, Jorge Katz, and William T. Beck, NBER Working Paper 101, August 1975.

"The International Transfer of Semiconductor Technology through U.S. Based Firms," by William Finan, NBER Working Paper 118, December 1975.

"Transnational Activity and Market Entry in the Semiconductor Industry," by Arthur Lake, NBER Working Paper 126, March 1976.

"Multinational Firms and the U.K. Pharmaceutical Industry—A Study of Innovation and Imitation," by Arthur Lake, revised version, April 1976.

"Exports and Foreign Investment in Manufacturing Industries," by Robert E. Lipsey and Merle Yahr Weiss, NBER Working Paper 131, revised version, May 1976.

"Bibliography on Technology and Trade," by E. I. Paulinyi, Mimeographed, August 1975.

Several of these are subject to further revision and a more intensive examination of factor substitution in overseas manufacturing is being undertaken as part of the project on trade regimes and employment in less developed countries, reported on by Anne Krueger.

One of the main topics was whether or not overseas production by affiliates of U.S. firms tended to substitute for production in the United States. Using several different approaches, we

found little evidence for such substitution and considerable evidence that overseas production increases exports. In one analysis we examined exports to 44 countries (or groups of countries) by the United States and 13 other major exporters, taking account of market size, the distance of each market from major suppliers, and membership in the EEC. Large U.S. affiliate production in a market was associated with comparatively large imports to that market from the United States but with small imports from other countries. Correspondingly, the presence of more affiliates of other countries in a market was associated with comparatively high imports from those countries but low imports from the United States. Thus each country's overseas production in a market appeared to displace exports by rival countries but to increase its own exports to that market.

Within the pharmaceutical industry a more intensive examination of trade-investment relations included a comparison among firms as well as among markets. This confirmed the results of the market cross-section on the whole, showing that a firm with comparatively high foreign production, relative to the size of the firm, also tended to export more, and a firm with relatively large production in a geographical area tended also to export relatively more to that area, given the size of the firm and of the market. The only indication of net substitution of foreign for U.S. production by an industry as a whole was in semiconductors, where the smaller companies, which invested little abroad, except for assembly, exported more relative to their size than the large firms, which did have major foreign production.

A good deal of attention was given to measuring the innovativeness of firms, since we wished to avoid dependence on measures of R&D input, such as ratios of R&D expenditures or personnel to sales. The most intensive effort was by Cohen, Katz, and Beck in which each new chemical entity, instead of being simply counted as an innovation, was rated as innovative or imitative through an examination of both the pharmacological action and the chemical class or structure of the drug. The output of innovative activity by a company was then measured as sales or numbers of innovative drugs.

This measure was not at all correlated with such conventional ones as R&D expenditures or personnel per dollar of U.S. drug sales. In the pharmaceutical industry, Lake, and in the semiconductor industry both Lake and Finan, made counts of innovations. Lake, in addition, constructed indexes of rank in introducing new products, with a first introduction in a country receiving a much larger weight than, say, a tenth introduction. Both Lake and Finan also calculated lags in introducing innovations.

Among the other topics considered in the papers were the effect of American licensing and subsidiary operations on the spread of innovations in foreign countries, the relation of the innovativeness of firms to their own policy on exporting and foreign production, and the nature of the comparative advantage of U.S.-based firms.

Mary Böger and Marianne Rey have had the main responsibility for data collection and programming during the past year at the National Bureau. We were again indebted to the Bureau of Economic Analysis of the U.S. Department of Commerce for the use of their data and to Arnold Gilbert and Michael Liliestedt of the BEA for programming calculations on those data.

Robert E. Lipsey
Irving B. Kravis

Price-Quantity Relations in U.S. Trade

This project, supported by the Office of Competitive Assessment of the U.S. Department of Commerce grows out of and extends earlier work on the role of prices in international trade, financed in part by the National Science Foundation. One of the two main elements of the project is a study of price and substitution elasticities in metals and machinery, the groups covered in our earlier volume on *Price Competitiveness in World Trade*. We now will have the benefit of annual time series covering a 20-year period and of disaggregation into comparatively homogeneous commodity groups at the three-digit or four-digit SITC level. For two-digit SITC classes we will have disaggregation of trade data into seven or eight geographical regions. The second aspect, on which we are now concentrating, is an examination of the relation be-

tween export and domestic prices in Germany, the United States, and Japan.

The study of export-domestic price relationships is based on the collection of detailed price data for exports and domestic sales, matched at the four-digit SITC level, for Germany, Japan, and the United States. These will include annual indexes for all three countries from 1953 through 1974 and monthly data for Germany and Japan starting in 1958 and 1953, respectively. Our earlier export price collection for Germany and Japan has been expanded to cover all manufactured products, as represented by SITC 5 through 8. We will also have domestic price indexes, for all manufactures, for the United States and the United Kingdom, as well as Germany and Japan.

One use of these price data is in tracing the transmission of inflation from one country to another, particularly to one with less inflationary policies. We expect to find that, for example, a rise in foreign prices, unless there are offsetting exchange rate movements, will first raise the ratio of foreign prices to the country's export prices, then the ratio of the country's export prices to its own domestic prices, then the ratio of domestic prices of traded goods to those of non-traded or less-traded goods, and finally, the price of non-traded goods. We hope to find out something about the lags involved in these changes, whether they differ from one commodity group to another, what shifts in trade result from the various changes in relative prices, and the effects on this process of the move to flexible exchange rates. A paper entitled, "The Adjustment of Domestic Prices to Foreign Price Changes," based on this study, was presented at the September 1976 meeting of the American Economic Association.

Mary Böger and Marianne Rey carried out the main data collection and programming on this study during the past year.

Irving B. Kravis
Robert E. Lipsey

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

In 1975 the NBER continued to 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. The Bureau has two of the five topics presently assigned in the area of application of computers to management. The program chairman for the U.S. operation is Dr. D. D. Aufenkamp of the National Science Foundation. The Bureau's part in the program is funded under an NSF grant award.

Meetings of the U.S.-U.S.S.R. coordinators and experts continued during the year. Programs included information exchanges, conferences, seminars, visits and further definition of longer term joint research.

April 20 to May 4, 1975, a Soviet delegation of six experts led by Dr. N. P. Lebedinskiy, Deputy Chairman of GOSPLAN and Head of the Main Computing Center of GOSPLAN visited the United States to observe computer applications in agricultural, reclamation and production processes. The National Bureau arranged for the delegation to visit the Gates Rubber Co. and Gates Cyclo Inc. in Denver, Colorado; the Bureau of Reclamation in Denver and Loveland, Colorado; Colorado State University, Ft. Collins, Colorado; Farr Farms, Montfort, Colorado, and Allard Ranch, Greeley, Colorado; the Ford Motor Company, SESCO Inc., and the Cross Co. in Detroit, Michigan. The delegation also visited with Senator Edmund Muskie and staff of the Senate Committee on the Budget, Representative Al Ullman, Chairman of the House Ways and Means Committee, Secretary of Treasury William Simon, James Lynn, Director, Office of Management and Budget, Governor Henry Wallich of the Federal Reserve Board, and Assistant Secretary of Interior Jack Carlson.

Dr. Lebedinskiy addressed the Economic Club of Detroit on planning in the Soviet Union. At the Woodrow Wilson International Center in Washington, D.C., Dr. Lebedinskiy had a discussion with scholars from the Institute for Advanced Russian Studies of the Center.

The group also visited National Bureau offices in New York and Washington and a protocol of the visit and future activities was signed by the topic coordinators at the conclusion of the visit.

In July 1975 a joint seminar on transportation

modeling and planning was held at the Main Computing Center of GOSPLAN in Moscow. The U.S. delegation, led by John Meyer, included E. K. Smith and J. Royce Ginn of the National Bureau; Morton Ehrlich of Eastern Airlines; Faye Johnson, IBM; Holland Hunter, Haverford College; Gregory K. Ingram, Harvard University; Paul Roberts, Joseph Sussman, and Marvin Manheim, M.I.T.; and Robert Dial of the Urban Mass Transportation Administration. Soviet side participants were B. S. Kozin, I. T. Kozlov, G. G. Tsomai, I. A. Oleinik, Z. I. Mozgrina, V. A. Zhzhikashvili, B. E. Marchuk, and V. S. Bondarenko. Seventeen papers were presented at the seminar and publication of a joint volume is planned. The U.S. papers have been assembled with an introduction by Holland Hunter and a revised version of the Soviet papers has been received.

The U.S. delegation to the transportation seminar visited computer installations and were briefed on management operating systems at several Soviet transport centers including the Department of Civil Aviation, the Department of Sea Transportation, and Moscow Truck Transport Center and the control center for the Moscow subway system. The delegation observed the work of the Department of Motor Transportation of Georgia in the capital city of Tbilisi and met with the planners of the Abkhasian Autonomous S.S.R. and Georgian S.S.R. for extensive discussion of transport planning. They also visited the Central Economics-Mathematical Institute of the Academy of Sciences and the State Committee for Science and Technology. The protocol of the visit was signed in Moscow July 9 by coordinators for Topic 2, Harvey J. McMains for the U.S., and V. B. Bezroukov for the U.S.S.R.

A meeting of coordinators and experts on Topic 1 was held in the United States in September 1975. The U.S.S.R. delegation was headed by A. A. Modin, Deputy Director of the Central Economics-Mathematical Institute of the U.S.S.R. Academy of Sciences. In addition to Professor Modin, the delegation consisted of V. M. Ioffe and B. O. Suvorov of CEMI and N. A. Kudinov of the State Committee of the U.S.S.R. Council of Ministers on Science and Technology. John Meyer, Harvey McMains, and E. K. Smith repre-

sented the United States.

The Soviet delegation visited National Bureau offices in New York, Cambridge, and Stanford for discussion and presentations by Bureau staff. Visits were arranged with the Cowles Foundation at Yale, Supermarkets General Corp., Woodbridge, New Jersey, Harvard, M.I.T., Stanford, and the University of California at Los Angeles; John Hancock Life Insurance Co., and the RAND Corporation. In Washington, D.C. the delegation visited the National Science Foundation, U.S. Department of Commerce, and the Council of Economic Advisers. Our visitors were exposed to a very wide range of research and research applications, involving advanced econometric models as well as computerized applications in marketing, data banks, networking, operations research, and optimal control systems among other subjects. A protocol was signed by John Meyer at the conclusion of the visit.

A seminar on econometric modeling methods originally planned for September 1975 in Moscow was postponed, at the Soviets' request, until June 1976. The U.S. papers were discussed prior to the Moscow meeting by members of the U.S. delegation at a seminar held at Sterling Forest, New York in October 1975. The U.S. side was chaired by Robert Dorfman of Harvard University. Other members of the delegation included Gary Fromm and Edwin Kuh of the National Bureau; Lawrence R. Klein, Ross Preston, and Donald Green, University of Pennsylvania; Clopper Almon, University of Maryland; Phoebus Dhrymes, Columbia University; Leonid Hurwicz, University of Minnesota; Franco Modigliani, M.I.T.; Dale Jorgenson, Harvard University; and Henri Theil, University of Chicago. The U.S. and U.S.S.R. papers will be assembled and published with an introduction by Donald Green.

In April 1976 a coordinators meeting was held in Moscow to discuss implementation of previously agreed upon plans and to discuss further cooperation in 1977. Some of the future plans include a seminar to be held in the United States on management information systems and one on managing large-scale agricultural enterprises, to be held in the U.S.S.R. (Topic 2). Two conferences on regional economic and mathematical models (Topic 1) have been proposed during 1976 and 1977. Subjects include regional

economic development models, applied migration studies, and industry studies. There are also proposals for longer term visits by U.S. scholars to the Institute for Economic Studies in Novosibirsk and by Soviet scholars to the University of Alaska on northern region studies and transportation scholar exchanges. Other longer term visits involve Soviet and U.S. scholars actively cooperating on research of mutual interest proposed from subtopics agreed upon, such as energy modeling, national planning, etc.

A visit to the United States by Academician N. P. Fedorenko of CEMI, U.S.S.R. Academy of Sciences is planned during the present year.

The Bureau has continued to exchange publications on the topics with our Soviet counterparts. The materials received from the Soviet Union are catalogued and deposited in our New York library and are available to the academic, business, and government community.

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

Trade Adjustments in Less Developed Countries (LDC's) to Exchange Rate Changes

Since the start of my fellowship in mid-August 1975 my research has produced three papers on some aspects of LDC foreign trade relating to the effects of exchange rate changes. "Effects of Major Currency Realignment on Philippine Merchandise Trade," which will be published in *The Review of Economics and Statistics*, suggests a theoretical framework for evaluating the direct trade effects on a small LDC of currency exchange rate changes among developed countries and examines the extent to which Philippine import and export flows have been affected by the 1971 realignment of the world's key currencies sanctioned by the Smithsonian agreement. The empirical results indicate an appreciable impact on the magnitude and pattern of Philippine merchandise trade and illustrate the kind of adjustment by small, open LDC's to this new form of external economic disturbance.

The two other papers are being circulated in preliminary form for prepublication comments. In "Import Demand in a Small Country with

Trade Restrictions," which was accepted for presentation at the European Meeting of the Econometric Society held in Helsinki in late August 1976, I develop a model of import demand taking into systematic account the existence of trade controls and the interaction between the domestic markets for imports and the competing home produced commodity. In application to Philippine imports of food in the post-war period, analysis of the estimated structural and reduced-form coefficients confirms some comparative static properties of the model concerning the bias contained in parameter estimates derived from single equation models of import behavior. One important finding is that failure to include the interaction effects considered in the model could lead to a substantial overestimation of the import response to exchange rate changes.

In my latest paper, "Interrelated Products and the Elasticity of Export Supply in Developing Countries," I formulate a "small country" model of export supply involving two related commodities, namely, a primary product and a processed commodity which uses the primary product as the principal material input in production. Under certain conditions it is shown that a currency devaluation would favor an increase in exports of the processed commodity relative to the primary product. In such a case the well-known tendency of LDC's to overvalue their currencies has the effect of discriminating against exports of processed commodities among related export products. Application of the model to Philippine postwar exports of copra and coconut oil, which jointly account for about thirty percent of the country's annual export earnings, illustrates quantitatively the significance of the cross-substitution effects and the associated reduction in export response to changes in the exchange rate and export prices.

I am currently developing a model of trade adjustments to multilateral exchange rate changes that would serve as a framework for analyzing the effects on world exports of a primary commodity (or a group of related products) and on the export earnings of a single country from the commodity. The empirical application will focus on world production and trade of coconut products involving the Philippines, Sri Lanka, Indo-

nesia, and Malaysia as major producers and several developed countries as major consumers.

Romeo M. Bautista

Foreign Trade Regimes and Economic Development

This project, started in 1970 under a research contract with the Agency for International Development and now in its concluding stage, has had several principal aims. One has been to develop a better understanding of the composition of exchange control regimes, frequently exceedingly complex, in which so many developing countries have become enmeshed in the effort to manage their balance of payments problems, assign foreign exchange receipts to purposes deemed most essential, and promote domestic production of goods previously imported. Against the background of that analysis of the make-up of foreign trade regimes, a further aim has been to study their effects on economic efficiency, including both allocation of resources and various growth aspects. Given the efforts made by the countries in question to simplify their trade regimes and to reduce distortions, a final major aim has been to examine the processes and consequences of liberalization and the conditions making for success or failure.

Of the ten country studies undertaken as a basis for exploring these questions, nine have been completed and published; i.e., those on Turkey, Ghana, Israel, Egypt, the Philippines, India, South Korea, Chile, and Colombia. The one on Brazil has not yet been completed for publication, but has yielded significant results embodied in a comprehensive paper presented at the seminar on the project held in Bogota in April 1975 under the joint sponsorship of Banco de la Republica, the U.N. Economic Commission for Latin America, and the National Bureau.

Largely on the basis of the information and analyses embodied in the country studies, two syntheses are being prepared, one by Jagdish Bhagwati on "Anatomy and Consequences of Exchange Control Regimes" and the other by Anne O. Krueger on "Liberalization Attempts and Consequences." Both of these reports,

after passing through several stages of discussion and revision, are in near-final draft and will soon be ready for review by the Board of Directors.

Jagdish N. Bhagwati
Anne O. Krueger

The Growth and Structure of Labor Absorptive Capacity in Latin American Manufacturing Industries

In this recent study, we are reexamining the problem of low employment capacity of the Latin American manufacturing sector. A dynamic absorption model has been developed to examine the determinants of the aggregate level and changing structure of employment in different manufacturing industries in ten Latin American economies.

The dynamic labor absorption model is derived from the neo-classical demand for labor model. Explicit account is taken of the technological features of an industry, the nature of the product demand changes in relative input prices and terms of trade, and the adjustment mechanism underlying employment behavior.

The estimation technique utilized in this study is a pooled cross-section time series method that permits analysis of changes in employment among different industries and the evaluation of the structure of employment over time. The analysis permits for a specific country, inter-industry comparison of employment behavior over time variations, and an over time inter-country comparison of employment for a given industry. These comparisons will help explain how the aggregate level and structure of employment are determined and what factors are responsible for the low employment absorption of the Latin American industrial sector.

The main body of data on Latin American manufacturing industries is obtained from the U.N. annual publication *Growth of World Industry*. The data from this source are fairly consistent and rich in content, but little used by researchers. Data for twenty-two manufacturing industries at a three-digit level for ten Latin American countries for the period 1963–1973 are utilized to estimate the model.

Patricio Meller
M. Ishaq Nadiri

6. MEASUREMENT METHODS AND OPERATIONS

The NBER Computer Research Center

Introduction

The NBER Computer Research Center for Economics and Management Science entered its sixth year of operations in February 1976. 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 both within and beyond the NBER can utilize the Center's products by means of a national data-communication network maintained by the NBER's Computer Service. Following are reports on major projects under way at the Center.

Edwin Kuh

Energy-Modeling System

The Center's programming staff is now complet-

ing the development of basic software for an Energy-Modeling System. The broad goal is to develop comprehensive, time-shared computer tools for economic analysis of contemporary energy problems; these tools include capabilities for building, testing, and linking econometric models and optimization models.

The system design calls for two levels of software: control/programming software, and application (problem-solving) software. The control software includes the operating system ACOS and the programming languages ACOL and DASEL. The application software includes subsystems for entering, estimating, and simulating econometric models, and for various mathematical programming tasks. In general, the control software provides the foundation on which the application software is built.

ACOS, the application-control system, has been used to create a few small application systems, and more are being developed. The ACOL

command language has been valuable in developing interactive applications; Dave Boyajian, Tom Dailey, Walt Oney, Dave Rice, and Annette Somers have been working on the implementation of ACOL. Somers is also rewriting the reference manual for ACOL to bring it up to date for first users outside of the Center. We have had some feedback from the first users and are preparing to gather more feedback by designing features that will give accurate data on the use of the system, indicating which parts are difficult to use and which parts work well.

Oney has been working on the ACOS supervisor. This will enable concurrent users to share programs and files, and will generally improve system performance. He has also completed the first part of what we hope will become a complete report-generator facility.

DASEL, a programming language for mathematical algorithms, has been used in a few applications. These suggest that DASEL is substantially easier to use and more productive than PL/I or FORTRAN for applications in statistics and econometrics. Further, our preliminary experience suggests that DASEL is easier to use and more powerful than APL. Joan Zahorjan has done almost all of the designing and coding of DASEL. Rice is now maintaining it and making improvements in response to feedback from users.

Roy Marsten and his colleagues have made substantial progress on the design of a generalized language and subroutine package for mathematical programming (see Marsten's report below). This work will form the basis of the mathematical programming capabilities of the Energy-Modeling System.

Mark Gelfand and Richard Wilk have been designing the regression and simulation components of the Energy-Modeling System. External specifications have been drafted, circulated for review, and revised. We are beginning to put the internal design in final form.

We have received valuable feedback on the design of the Energy-Modeling System from an advisory committee that includes representatives of several energy-research centers. In particular, we have been in close touch with the Brookhaven National Laboratory, the MIT Energy Laboratory, the Transportation Systems

Center of the U.S. Department of Transportation, and energy-related research projects headed by Professors Martin Baughman and Olin Johnson at the University of Texas (Austin) and the University of Houston, respectively.

Richard Hill
Gerald Ruderman

Alaska Model

Research to develop policy-planning models of the Alaskan economy is being conducted jointly with the University of Alaska's Institute of Social, Economic, and Government Research (ISEGR). This work is part of the Man in the Arctic Program (MAP), which has been funded by the National Science Foundation, Office of Polar Programs. In the spring of 1976 MAP completed its first three-year phase and began a second three-year phase, again with NSF funding. I spent the last two years in Alaska as director of MAP and will continue in the second phase as co-principal investigator with Victor Fischer of the University of Alaska.

The principal objectives of the first phase of MAP were to construct models for analyzing long-run economic and population change in Alaska, and to begin to use these models in key policy applications. This work was designed to provide information for those responsible for policy planning and decision making that will affect Alaska's future development. Interactive economic and demographic computer models were constructed on both statewide and regional bases. On the basis of such factors as location, size, and timing of federal, state, and native oil and gas developments; alternative energy prices; and state fiscal policies, the models have been used to project through 1990 the growth in gross state product, personal income, industrial employment, population, per capita income, etc. The models have been used to analyze specific policy issues such as alternative rates of petroleum development, state leasing in the Beaufort Sea, and alternative gas pipelines from the North Slope.

Both the statewide and regional Alaska models have been converted by Bob Chen to be operational on NBER's TROLL system. The MAP researchers in Alaska are linked to TROLL

through the Seattle node of NBERNET, the NBER telecommunication network; and all of the final simulations for the 1990 projections and policy analyses were carried out on TROLL. Because of its flexibility, all further developmental work is being carried out using TROLL and the NBER computer. By using a common computer environment, model modifications originating either in Cambridge or in Alaska are immediately accessible to researchers in the other location.

The second phase of MAP is intended to deepen and extend the capacity for policy analysis, particularly concerning the distribution of the economic and social costs and benefits of developing Alaska's energy resources. The NBER energy-research program will provide links between the Alaska energy studies and national energy models and projections.

While all MAP economic research will be undertaken jointly by ISEGR and NBER, different primary responsibilities have been assigned to each institution. The bulk of the basic data-collection and analysis will be carried out by ISEGR economists in Alaska, as will implementation of the MAP models to carry out policy analysis. Personnel at NBER Cambridge will be principally responsible for developing the computer models used in the MAP research. Further, any large-scale data processing will be done in Cambridge using the National Bureau computers. Both the model development and data processing will take full advantage of the expertise and software available through the NBER Computer Research Center.

David T. Kresge

Experimental Mathematical Programming Systems

During the past year we have conducted experimental research in two new areas of mathematical programming: nondifferentiable optimization and parametric integer programming. The maximization of a nondifferentiable function is a difficult problem for which there are many applications, but few available computational methods. Since one of these applications is solving the dual of an integer program, this work is relevant to Jeremy Shapiro's work on con-

structive duality for integer programming. The experiments which were carried out compared my own method, Boxstep, with the subgradient optimization method on problems arising from facility-location planning, production planning, and machine scheduling. I presented the results at the 47th National Meeting of the Operations Research Society of America in Chicago in May 1975 and wrote a paper which appeared in a special issue of *Mathematical Programming* devoted to nondifferentiable optimization.

The study of sensitivity and parametric analysis for integer programs began in earnest in 1975. During the year several working papers and dissertations made substantial contributions to this new area. With Thomas Morin of Purdue University, I wrote the first computer code that can solve families of integer programs parameterized on the right-hand-side (resource availabilities); we were assisted in this effort by Michael Harrison. We described the algorithm in "Parametric Integer Programming: The Right-Hand-Side Case" (NBER Working Paper 106, October 1975); this paper was presented at the Workshop on Integer Programming in Bonn, West Germany in September 1975 and will appear in the *Annals of Discrete Mathematics*.

Thomas Morin and I have also collaborated on a new approach to discrete mathematical programming. This involves a synthesis of the dynamic programming and branch-and-bound methodologies. With the assistance of Michael Harrison we have implemented our hybrid algorithm in an experimental computer code. This code uses linear programming in a novel way to compute bounds and to share them among the nodes of the search tree. Preliminary computational results have been encouraging and were presented at the 49th National Meeting of the Operations Research Society of America in Philadelphia in April 1976. A paper on the hybrid algorithm has been submitted to *Mathematical Programming*.

Over the past year Michael Harrison, Robert Fourer, William Northup, and I have been engaged in continuing discussions concerning the form of an "ideal" computer system for experimental research in mathematical programming. Such a system would have two main parts: a highly modular linear programming code and a

high-level language for specifying linear programming models. The modular LP code would be designed in a top-down hierarchical fashion so that the experimenter could intervene at whatever level was necessary for his particular purpose. Such a code would benefit at least four classes of experimenters: those who wish to experiment with the simplex method itself; those who wish to use the simplex method as a subroutine in a more complex algorithm; those who need only certain parts of the simplex method as steps in some other algorithm; and those who wish to use linear programming in conjunction with some other methodology such as econometrics.

We also envision a modeling language which would be a radical departure from presently available matrix generators and report writers. Such a language would permit the user to define or modify a model in a way that is very close to standard mathematical practice; that is, the point of departure would be the mathematical statement of the model rather than the coefficient matrix. Such a high-level approach would result in a system that is both easier to use and much more efficient in terms of computer-processing time than existing systems. We have carried these discussions to the point where we have a clear idea of the general outline of such a system and are planning a descriptive paper for a conference on mathematical programming software being sponsored by the Association for Computing Machinery and the National Bureau of Standards in Gaithersburg, Maryland in November 1976.

Roy Marsten

Mixed Integer Programming

Work this year has centered on integer programming duality theory and its integration into the mixed integer programming problem. Mixed integer programming dual problems provide a base for sensitivity analysis and multicriterion optimization. In addition, algorithms for solving these dual problems, or for approximating their solution, can serve as an important adjunct to linear programming in a branch-and-bound strategy for solving the mixed integer programming problem. To this end, Bill Northup incorpo-

rated some of these methods into a large-scale branch-and-bound mixed integer programming system that uses the SESAME linear programming system for its simplex algorithm and for its data base.

Roy Marsten, Bill Northup, and I are experimenting with subgradient optimization as an alternative to the simplex algorithm for solving subproblems in a branch-and-bound setting. We are augmenting the method, more closely approximating the integer programming dual of the subproblem using group theory, and we are treating a larger class of problems than the set-partitioning and covering problems for which the method was first proposed. We have implemented integer programming models for water-resource planning, for mine scheduling, and for nuclear reactor refueling.

For a class of scheduling problems we are experimenting with alternative Lagrangian relaxations and alternative methods for their dual optimization. We are also experimenting with a hybrid primal-dual technique to solve MIP dual problems directly, as an alternative to explicitly decomposing the problem into integer and continuous subproblems.

Bruno Simeone, a visiting scholar from the Consiglio Nazionale dello Ricerche, Rome, is studying group theoretic cuts for the integer programming problem. In September 1975 I presented a paper entitled "Sensitivity Analysis in Integer Programming" at the Workshop in Integer Programming sponsored by IBM Germany in Bonn.

Jeremy F. Shapiro

Robust Statistics

The goal of this project in which interdisciplinary research is conducted in robust statistics, numerical analysis, and quality software, is to develop numerically and statistically reliable FORTRAN IV subroutines that operate efficiently on a cross-section of major U.S. computers, including the IBM 360/370, CDC 6600/7600, Univac-1108, PDP-10, and Honeywell-6000. The group of subroutines is referred to as ROSEPACK (Robust Statistics Estimation Package). ROSEPACK will implement a substantial portion of modern theoretical work on robust fitting of

linear and nonlinear statistical models.

Work on ROSEPACK began in May 1975, with Paul Holland and me as co-principal investigators. The first phase of this work was concerned with the robust fitting of linear models. In the second phase, which began in May 1976, we seek to refine the first phase, but concentrate more heavily on robust fitting of nonlinear models; Gene H. Golub and I are the co-principal investigators.

During the period May–December 1975 the main focus of research was on the form of the covariance matrix for robust regression methods in ROSEPACK. Previous work of Richard Hill and Holland (“A Monte Carlo Study of the Robust Alternatives to Least Squares Regression Estimation,” NBER Working Paper 58, September 1974) was extended to evaluate the possibility of setting conditional confidence intervals where the conditioning is on the weights that are calculated from the data. This work involved a Monte Carlo study directed by Holland, David Hoaglin, and Roy Welsch; the programming for this study was done by Stanley Wasserman. The Hill-Holland paper is being revised in light of this research and will be submitted to the *Journal of the American Statistical Association*. Further results were presented by Welsch in an invited paper at the Statistical Computing Section of the 1975 Annual Meeting of the American Statistical Association (Atlanta, August 1975); see report by Welsch below.

David Hoaglin, with the programming assistance of Stanley Wasserman, has designed an automatic stem-and-leaf display for data analysis. They have published this work in “ROSEPACK Document No. 2: Automating Stem-and-Leaf Displays” (NBER Working Paper 109, November 1975) and are also submitting the paper for journal publication.

With the programming assistance of Neil Kaden, I have been working on problems of building robust statistical software. Basic to this software are semi-portable numerical algorithms, i.e., algorithms that are coded in FORTRAN IV and can be used on various machines. Equally basic are the underlying numerical algebra modules for the higher-level computations.

The singular value decomposition is the most frequently used tool of numerical algebra for

our computations. In particular, strong or weak dependencies in the columns or rows of a matrix can be isolated. Further analysis of the singular vectors associated with small singular values leads to the effect on the data induced by changing the rank-deficient data matrix to one of full rank. The results of this work are being submitted for publication by G. H. Golub, G. W. Stewart, and me. A report on rank dependency and least squares problems was presented at the National SIAM Meeting, San Francisco, December 1975. A paper that explores the use of the singular value decomposition by statisticians will be submitted for publication by Holland and me. The FORTRAN code for the dependency analysis and certain results of the computation are also to be submitted for publication.

An important goal of this project is a clean-cut guide for writing and testing semi-portable robust software. Certain requirements for writing semi-portable FORTRAN and preliminary guidelines for writing ROSEPACK subroutines have been specified by Kaden and me in “ROSEPACK Document No. 1: Semi-Portability of FORTRAN Programs” (NBER Working Paper 103, September 1975) and “ROSEPACK Document No. 3: Guidelines for Writing Semi-Portable FORTRAN” (NBER Working Paper 130, March 1976).

Virginia Klema

Nonlinear Algorithms

In the past year we have explored several promising leads in unconstrained optimization and the solution of nonlinear equations. One major task has been the implementation and testing of a new algorithm for solving both the nonlinear least squares problem and more general robust estimation problems. It incorporates several recent ideas that aim at improving computational efficiency and reliability. Some of these ideas are due to John Dennis, who designed the basic algorithm with inputs from Virginia Klema, Roy Welsch, and me. Mark Gelfand coded the initial design into a convenient package called DMINIMIZE, which he, Roy Welsch, and I continue to test and modify. Implementation details (such as just how iteration values should be updated) remain to be settled, but the present

version performs well on standard test problems.

Researchers developing unconstrained optimization algorithms often limit the testing of their computer codes to a few standard test problems which have frequently appeared in past publications and which have been contrived to test certain features of the optimization codes. John Dennis and I have begun efforts to identify "real-life" test problems from among those encountered by other researchers at NBER and elsewhere. Such test problems should be valuable to researchers in unconstrained optimization (including those at both NBER and Argonne National Laboratory, with whom we are collaborating). We expect to devote more effort to this endeavor in the coming months.

As an experiment in the modularization of software for unconstrained minimization, I have begun developing modules and a general framework into which they fit. Part of the purpose is to test the hypothesis that it may be wise to use one method to come close to a solution or to build an initial Hessian approximation (while moving toward the solution), then switch to a second method to more quickly compute the solution to the desired accuracy. The hybrid minimization framework HYBMIN is designed to allow various combinations of methods, including conjugate gradient and quasi-Newton methods; one interesting possibility which we soon hope to explore with this system is that of using the new conjugate gradient scheme of Larry Nazareth (Argonne National Laboratory) on the optimization problem arising in Kent Wall's optimal control system. In connection with developing quasi-Newton update modules, I wrote a paper on "Representing Symmetric Rank-2 Updates" (NBER Working Paper 124, February 1976).

Sometimes one encounters estimation problems in which the number of independent parameters is not known beforehand. This happens, for example, if one tries to fit polynomials to some data without knowing what degree polynomials to use. If one guesses too many parameters, then one obtains an objective function whose Hessian is singular or nearly so. In this and the more general case where it is neces-

sary to solve a system of nonlinear equations whose Jacobian matrix is (nearly) singular, it is natural to ask how to reasonably avoid numerical difficulties and compute a sensible solution. I have designed and coded a module which deals with this question in the robust (and nonlinear least squares) estimation case in what Roy Welsch and I feel to be a reasonable way. My paper "On Modifying Singular Values to Solve Possibly Singular Systems of Nonlinear Equations" (NBER Working Paper 125, March 1976) addresses this question in the more general case and points toward some possible future research.

David M. Gay

Statistical Data-Analysis Methods

In the past year I have continued my work on aggregation, multiple comparison procedures, nonlinear robust regression, and confidence regions for robust linear regression. I have also begun work on the uses of sensitivity analysis in statistics and econometrics and have served as co-chairman of the Ninth Annual Symposium on the Interface between Computer Science and Statistics.

My work with Edwin Kuh on theoretical questions of aggregating economic data ("The Variances of Regression Coefficient Estimates Using Aggregate Data" *Econometrica*, March 1976) has been tested and confirmed by a detailed Monte Carlo study. We found that the degree of synchronization, as reflected by the average micro correlation, exerts a highly strategic influence on the macro parameters. The higher the synchronization, the greater the gains from aggregation. We also discovered that collinearity can substantially diminish otherwise beneficial effects of aggregation on macro variances. This work appears in "A Monte Carlo Study of Aggregation Effects on Regression Parameter Estimates" and has been submitted for publication.

This year I completed work on a paper entitled "Multiple Comparison Procedures Based on Gaps," which proposes four sequential multiple comparison significance tests designed to control the experimentwise type-I error rate. Tables for the gap tests were constructed using improved Monte Carlo techniques. A simulation

study showed one of the gap tests to be best and this test provided significantly greater power than the commonly used Tukey Honestly Significant Difference procedure.

In the field of nonlinear robust regression, I have been working with John Dennis and David Gay to develop a new algorithm for solving both the nonlinear least squares problem and the more general robust estimation problem. I have worked on methods to approximate the "second-order" part of the Hessian (see report by David Gay above) and on strategies for using the double dogleg confidence region to determine when to use the approximate second-order part of the Hessian. I have also proposed ways to handle the scaling problems that occur in robust estimation.

A study of ways to approximate the covariance matrix of robust regression estimators was completed and the results appear in "Confidence Regions for Robust Regression," *Proceedings of the Statistical Computing Section of the American Statistical Association 1975*. We found that for design matrices with columns of modest kurtosis, the standard weighted least squares output using data-dependent weights need only be modified slightly by changing the t -statistic degrees of freedom from $n-p$ to approximately $(n-p)/2$ and using an adjustment factor derived from asymptotic theory.

During the year we have begun to develop techniques to assess the robustness of econometric models in the presence of moderate departures from modeling and estimation assumptions. The objective is to improve the reliability of econometric models by providing tools to assess and perhaps improve their robustness. These diagnostic tools blend certain ideas relating to elasticity and parameter variation in economics with the concepts of robustness and the jackknife in statistics, sensitivity analysis in mathematical programming, and perturbation theory in numerical analysis. An NSF grant has been obtained which will allow us to test these procedures extensively during the coming year.

Roy E. Welsch

Errors-in-Variables Model

This investigation focused on the performance

of the canonical estimator for the errors-in-the-variables (EV) model—the estimator which results from taking the orthogonal regression of variables rescaled according to the covariance matrix of the errors.

I found that this estimator is highly nonrobust to departures from the normality-of-errors assumption, indeed to a degree which relegates it to use only in large samples on data displaying no trace of "outlier contamination." I proposed a "robustizing" modification of this estimator, which down-weights apparent outliers; and I showed that this modification is robust to outlier contamination even in small samples, given a sufficiently good "preliminary" estimator. These findings appear in my paper "Robust Line Estimation with Errors in Both Variables" (NBER Working Paper 83, May 1975). The problem of obtaining a preliminary estimator has not yet been solved.

This work on the EV model is related to the Center's current research in robust regression. For example, the proposed robustizing modification of the classical EV estimator is a generalization to EV of the W -estimator for robust regression (Beaton and Tukey, "The Fitting of Power Series" *Technometrics*, Vol. 16, No. 2, May 1974).

Michael L. Brown

Estimation of Simultaneous Equation Systems

Two major estimation techniques have been added to the GREMLIN simultaneous-equation estimation system: nonlinear three-stage least squares (NL3SLS) and nonlinear full information maximum likelihood (NLFIML). Both systems have been successfully tested on simultaneous systems ranging in size from two equations with five parameters to 13 equations with 63 parameters. Preliminary experiments indicate that NLFIML can be computationally competitive with NL3SLS for equation systems within this size range. Further experiments were required to see if NLFIML could be made even more practical for typical econometric use; these were completed this summer.

The NL3SLS facility allows the user to enter a model efficiently, in standard symbolic equation form. A Davidon-Fletcher-Powell minimiza-

tion routine is used. The facility also allows for iterative three-stage least squares (useful in estimating a model with a singular error structure) and iterative Zellner estimation as a special case.

Preliminary studies with NLFIML on several models differing in number of equations, number of parameters, and degree of nonlinearity are encouraging. NLFIML is hardly more expensive than NL3SLS for small models (six parameters) and may only double the cost for larger models (60 parameters). NLFIML may prove even more competitive, for several important computational shortcuts have not yet been exploited. Experiments with several of these shortcuts are currently underway, and their results should be ready by the end of the coming summer.

There are two costly elements to the computation of NLFIML estimates: multiple iterations to convergence and the calculation of the Jacobian sum. The usual convergence criterion of a zero gradient may indeed be more stringent than is required for most econometric purposes. Further, it is scale-sensitive and can cause many needless iterations if the economic data have not been properly scaled beforehand. We have developed a convergence criterion that is not scale-sensitive and that may allow acceptable parameter estimates to be obtained with significantly fewer iterations. Preliminary results are encouraging.

Other experiments will be conducted with a modified NLFIML package that approximates the computationally costly Jacobian term with a much simpler expression. The modifications to NLFIML that allow both these sets of experiments to be conducted have recently been implemented.

David C. Belsley

Qualitative and Limited Dependent Variables

Since the summer of 1975, the focus of the Center's work on qualitative and limited dependent variable models has been on development of software for the estimation and analysis of such models. The fruits of this effort consist of two completed and fully documented software subsystems—one for logistic models of quali-

tative choice behavior and the second for limited dependent variable models of the probit-Tobit variety.

During the previous year, probit-type programs had been prepared for experimentation with user interfaces and computational methods. Feedback from users of these prototypes, along with our own experiences, led to the design of the final software. That design incorporates objectives of reasonable computational efficiency, ease and flexibility of use, and comprehensiveness over applicable models and problems.

LOGIT, the qualitative variable program, performs maximum likelihood estimation on polychotomous logit models. It accepts independent variables which are attributes of either the choice maker or the alternatives in the choice set, replicated or nonreplicated samples, and models in which each observation may involve only a subset of the alternatives. Predicted choice probabilities and a variety of measures of fit are optional output.

LIMDEP, the limited dependent variable program, is designed around a general model that includes as special cases Tobit, probit, two-limit probit, ordinal-discrete, and friction models. It provides a high degree of flexibility in model specification and a variety of post-estimation analysis tools.

Programmers Mark Gelfand and Rick Wilk contributed substantially to the preparation of the two subsystems. Constructive criticism from users at Carnegie-Mellon, Harvard, Rochester, MIT, and several NBER offices proved highly beneficial.

Forrest D. Nelson

Optimal Control

An algorithm for the computation of optimal economic policies has now been installed on the TROLL system as a member of the TROLL Experimental Programs series. This algorithm is implemented under the name POLIOPT (for Policy Optimization); associated documentation has been completed and is being distributed to TROLL users.

The algorithm has been designed to meet the special requirements of the economic policy planner. The program accepts, without modifi-

cation, econometric models specified in the TROLL modeling language; the user does not need to transform his model from econometric form into state-space form. The measure of social welfare (welfare function) is specified as a piecewise quadratic function which allows asymmetric weighting and the tracking of target trajectories. Dummy equations expressing non-quadratic combinations of endogenous variables can be added to the model and then incorporated in the welfare function; in this way almost any conceivable welfare function can be constructed. In addition, the asymmetric weighting facility permits certain terms in the welfare function to be employed as penalty functions so that the inequality constraints on variables can be accommodated.

Once a problem has been specified by a model and a welfare function, the optimal instrument trajectories are computed via a "static" hill-climb on the welfare function using a variable metric (Davidon-Fletcher-Powell) technique. Upon convergence, the user may file all his results for subsequent use in simulation studies or plotting. The user can control the hill-climb phase by changing stepsize parameters and the convergence criterion.

The flexibility of POLIOPT is not without cost. The program cannot solve stochastic control problems explicitly; i.e., all additive disturbance terms must be assumed zero. Further, explicit feedback-control policies cannot be obtained, although POLIOPT can be used repeatedly to produce implicit feedback policies. Finally, POLIOPT imposes a size limitation: the total number of instrument values to be optimized equals the number of instrument variables times the number of intervals in the planning period. Computational costs vary nonlinearly with this product; when it approaches 100, alternate procedures should be sought. As a general rule, however, POLIOPT is expected to be useful for quarterly models with up to three instruments over a four to five year horizon. Linear quadratic test problems that involve sixty instrument values have been successfully solved, as have typically nonlinear, nonquadratic problems, like the Ando-Mini Model.

Kent D. Wall

Time-Varying Parameters

During the past year research has continued on theoretical issues of estimating time-varying econometric relationships, on improvements of the computational algorithms, and on applications. In addition, the methods used in estimating time-varying structures have been applied to estimating unobservable variables, particularly price expectations.

The growing literature on the estimation of models with time-varying regression coefficients has largely ignored the issue of the identifiability of such models and consequently has left in doubt the generality with which they can be specified. Last year's report discussed some preliminary results on the identification of such models; this research has been extended in the past year, and the complete identification conditions for models with time-varying coefficients have been established (Cooley and Wall, "Identification Theory for Time-Varying Models," NBER Working Paper 127, March 1976). These conditions show that time-varying coefficient models are not identified in their most general form, and that certain restrictions must be imposed on the process governing the evolution of the coefficients in order to estimate them.

Algorithms for estimating models with time-varying coefficients have been installed on the TROLL system and are now available to general users as part of the TROLL Experimental Programs series. These algorithms permit estimation of both filtered and smoothed trajectories of the time-varying coefficients. The smoothing algorithm avoids many of the pitfalls that have plagued other approaches to obtaining efficient estimates of the parameter trajectories. The algorithm is described in Cooley and Wall, "A Note on Optimal Smoothing for Time-Varying Coefficient Problems" (NBER Working Paper 128, March 1976).

Approaches to estimating time-varying regression coefficients draw heavily upon control theory. Many engineering problems for which control theory was initially developed focus on the estimation of unobservables. The unobservable problem in econometrics has received increasing attention in recent years and has stimulated our interest in applying the state-space

methods of control theory to the estimation of unobservables.

A common unobservable problem in econometrics is price expectations in dynamic economic models. In previous approaches, price expectations have been modeled as deterministic functions of past prices, or survey data has been used. Our current research focuses on an alternative approach: price expectations are treated as unobservable states to be estimated, and Kalman-filtering theory is applied to their estimation. Both macroeconomic and microeconomic examples are being considered.

In last year's report I discussed the use of varying-parameter methods in studying the formation of price expectations and the adaptation of 19th century farmers to changes in the structure of markets (Cooley and DeCanio, "Rational Expectations in American Agriculture, 1866-1914," NBER Working Paper 57, September 1974; revision forthcoming in *Review of Economics and Statistics*). This research is being continued on a larger scale using data on a wide variety of crops from the mid-19th century to the present. The goal is to study in some detail the processes of expectation formation and the adaptation of economic agents to changes in technology, government policy, and the structure of world markets.

Thomas F. Cooley

Other Computer-Oriented Activities

NBER Computer Service

The NBER Computer Service organization is responsible for the Bureau's central computer facilities and for disseminating the software developed by the Computer Research Center for Economics and Management Science. Responsibility for the central computer facilities includes 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.

In the spring of 1975 the Bureau transferred its block purchase of computer time from Yale

University (IBM 360/67) to Cornell University (IBM 370/168). This change was made to facilitate the software development work of the Computer Research Center and to allow all Bureau users to take advantage of the latest computer technology. This transfer went extremely well with the users experiencing only minimal inconvenience. The smoothness of this conversion is a tribute to the detailed planning and the many hours of hard work by the computer operations staff and those others who participated in this effort.

The TROLL system continues to be well-received by the research community. Use of TROLL, through NBER's central computer facilities, by academic and governmental organizations increased during the past year. Access to the NBER's computer facilities is made through Tymnet's nation-wide data communications network. Several European users have also accessed TROLL on NBER's computer facilities through Tymnet's European facilities. TROLL has also been well received in Canada and is being made available to academic, governmental, and commercial time-sharing users through the facilities of IBM Canada and S.M.A., Inc. (Société de Mathématiques Appliquées). TROLL is also running at the University of Grenoble, and will soon be installed at the Technical University of Berlin, the University of Vienna, RCA Global Communications, and at IBM's Cambridge (Mass.) Scientific Center. A number of other university computing centers and foreign governments have requested TROLL and steps are being taken to satisfy these requests.

During the past year, several commercial organizations expressed an interest in and requested access to TROLL on NBER's facilities. Due to various problems which arise when commercial companies use educational computer facilities, NBER has not been able to satisfy these requests. To overcome this shortcoming discussions have been held with commercial time-sharing companies concerning their making TROLL available to commercial companies. Negotiations are now underway with several time-sharing companies. TROLL is now available to commercial users through Tymshare, Inc. Tymshare will also make TROLL available to

large government units whose usage is greater than that NBER can provide for through its own facilities.

In addition to TROLL a new mathematical programming system, SESAME, which was developed by the Computer Research Center was made available for limited use by selected research groups. As more real world experience is gained with SESAME over the coming year, plans will be formulated as to how this system can be supported and given wider dissemination.

Warren Lackstrom

Time Series Data Bank

The demand for the Bureau's machine readable data bank of economic time series continues to grow. Internally, the time series data bank has always been used by all projects dealing with business cycle research and cyclical indicators, price behavior, inflation, monetary research, and by some projects dealing with unemployment, earnings and other labor market variables. It is now also used by the large project on the measurement of economic and social performance.

Apart from the increased use by internal research projects, the number of outside users has grown to about 160 in September 1976. This includes 23 colleges and universities. Most academic institutions require updated tapes only once a quarter. They use the data bank partly for empirical research, but primarily as a teaching tool in courses on econometrics, forecasting, national income accounting, and so forth.

A large part of the increase of nonacademic users consists of the clientele of time sharing companies which are either not specialized in economic research or too small to have their own data base, but who still have to provide their customers with national data series to meet competition. These time sharing companies buy our tapes once a month and put them up in their system. At present the following time sharing companies receive monthly updates: APL Services, Computer Science Corporation, J. P. Sharp, Multiple Access, National CSS, On-Line, Scientific Time Sharing Corporation, and Tymshare.

Time sharing companies whose data base we update on a daily basis are: GE Mark Delta System, Rapidata, Service Bureau Corporation, and Boeing Computer Services for Wharton EFA, Inc.

The workload of our staff has been particularly heavy in the last few months, primarily because of the extensive revisions of the National Income and Product Accounts. Unfortunately these revisions—just like most other revisions of economic time series—are not available in machine-readable form and thus have to be punched manually. In order to avoid duplication of this very time consuming task, we agreed to make our tape available to the Department of Commerce, as soon as we have completed the revisions. There is some reason to hope that in the future our life will be simplified by availability of machine-readable output generated by the computerization of large scale revisions of government data.

We are preparing substitution pages for our directory of code names in order to document the new series in the bank and to eliminate the ones we no longer carry. Since our current directory seems to present some difficulties to users who are not familiar with the printed sources of statistics, we are experimenting with a new format which will stress relationships among various series. Also, if the directory is to replace the printed source document, even to a very small extent, we will need more footnotes and explanations than we now have.

Since last year's report there has been a change in the data bank staff: Josephine Su has left the Bureau to start an international data bank elsewhere and Ann Wood has joined our staff. Ann has been at the Bureau since 1973, reorganizing the library, setting up microform facilities, and organizing our tape library (see report below). Connie Lim and Wah-Lee Hsu are still the backbone of the data bank operations.

Charlotte Boschan

Machine-Readable Data Files

The Bureau's collection of machine-readable data sets is well on the way to becoming a useful well-organized research tool. A directory of available data sets is maintained and documentation is kept on file. The research staff is coop-

erating fully with the present system which has been designed to avoid duplication of purchases, to provide documentation for data developed within NBER, and to maintain a general clearing house for this kind of information.

Although the tape library is primarily intended for internal use, we have had a number of outside requests for tapes which either originated in the Bureau or were processed, improved, or added to by the Bureau. The most important of

these are the NBER-Thorndike tapes which are now being used for two Ph.D. dissertations and one research paper. Outside requests for data tapes and their documentation have been stimulated largely by the publication of *Education, Income, and Human Behavior*, edited by F. Thomas Juster, New York, National Bureau of Economic Research, 1975.

Ann Wood

7. CONFERENCES, WORKSHOPS, AND OTHER PROGRAMS

Conference on Research in Income and Wealth

The proceedings of the 1973 Conference were published this spring as *Household Production and Consumption*, Volume 40 of Studies in Income and Wealth. *The Distribution of Economic Well-Being*, the proceedings of the May 1974 Conference, is to be published this winter as Volume 41. The proceedings of the 1974 Conference on Price Behavior are in press and the proceedings of the May 1975 Conference on the Economics of Residential Location and Urban Housing Markets are being prepared for press. The revised papers for the November 1975 Conference on New Developments in Productivity Measurement are being assembled and will be edited by the Co-Chairmen, Beatrice N. Vaccara and John W. Kendrick.

The next sessions of the Income Conference will be held on October 14–15, 1976 in Toronto under the chairmanship of Dan Usher. "The Measurement of Capital" is the subject for the conference and the following papers are anticipated:

New Estimates of the Capital Stock in the United States—Allan H. Young and John Musgrave, Department of Commerce

Income and Capital Gains—Robert Eisner, Northwestern University

The Measurement of Income and Product in the Oil and Gas Mining Industry—John Soladay, Pennsylvania State University

Aggregation Problems in the Measurement of Capital—Erwin Diewert, University of British Columbia

The Implications of Capital Perversities for the Measurement of Capital Growth—Murray Brown, State University of New York at Buffalo

Economic Depreciation—Charles R. Hulten, Johns Hopkins University and Frank C. Wykoff, Pomona College

The Value of Capital and Rates of Returns in U.S. Manufacturing—Robert M. Coen, Northwestern University

New Books on the Measurement of Capital: Reviews of Robert J. Gordon on "The Measurement of Durable Goods Prices" (in manuscript) and John W. Kendrick on *The Formation and Stocks of Total Capital* (published)

James D. Smith is planning a conference on wealth to be held in 1977.

The conference program is assisted by a grant from the National Science Foundation. Members of the Executive Committee are: Dorothy S. Projector (Chairman), Clopper Almon, Robert M. Coen, Stanley Lebergott, Geoffrey H. Moore, J. A. Sawyer, Dan Usher, Dorothy Walters, Burton A. Weisbrod, Allan H. Young, Mildred E. Courtney (Secretary).

Mildred E. Courtney

Universities—National Bureau Committee for Economic Research

The Universities—National Bureau Committee Conference on Population and Economic Change of Population Growth in Less Developed Countries (Richard Easterlin, Chairman of the Planning Committee) is to be held in Philadelphia on September 30 through October 2, 1976.

The following conference will be on Low Income Labor Markets (Sherwin Rosen, Chairman of the Planning Committee) to be held in 1977.

There are three Exploratory Committees on the following subjects: Taxation and Household Behavior (Martin Feldstein, Chairman); Economic Planning and Regulation (Richard Nelson, Chairman); and Economics of Information and Uncertainty (George Stigler, Chairman).

Two conference volumes have been published this summer. One is *The Role of Health Insurance in the Health Services Sector*, edited by Richard N. Rosett. The other is *Economic Analysis of Political Behavior*, which was published as the December 1975 supplement to the *Journal of Law and Economics. Education as an Industry*, edited by Dean Jamison, Joseph Froomkin, and Roy Radner will be published this winter.

There are now forty universities, in addition to the National Bureau, represented on the Committee. The participating universities are:

| | |
|---------------------------------------|-----------------|
| Brown | New York |
| California, Berkeley | New York State, |
| California, Los Angeles | Buffalo |
| Carnegie-Mellon | North Carolina |
| Chicago | Northwestern |
| Columbia | Ohio State |
| Cornell | Pennsylvania |
| Duke | Pittsburgh |
| Harvard | Princeton |
| Illinois | Purdue |
| Indiana | Queen's |
| Iowa State | Rochester |
| Johns Hopkins | Stanford |
| Maryland | Texas |
| Massachusetts Institute of Technology | Toronto |
| McGill | Vanderbilt |
| Michigan | Virginia |
| Michigan State | Washington |
| Minnesota | (St. Louis) |
| New School for Social Research | 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, Bela A. Balassa, Carl E. Beigie, Daniel Creamer, Frank

de Leeuw, 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. Lockett. 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)

The purpose of this conference is to stimulate discussion and research on the frontiers of the state-of-the-art of econometric and mathematical economic theory and methodology and the application of advanced mathematical, statistical, and numerical analysis techniques in empirical economic studies. The conference is organized in seminar groups which meet periodically at leading universities and research centers throughout the United States. Participation in the seminars involves a changing set of senior and young scholars depending on topic and research being conducted in the field.

Since November 1970, thirteen different seminar groups have been formed. These have met at universities and research centers throughout the country—for example, at Harvard, M.I.T., University of California-Berkeley, Northwestern, Iowa, Carnegie-Mellon, the NBER, Michigan, Princeton, Minnesota, Yale, Pennsylvania, and Chicago. A total of 60 meetings have been held, involving more than 300 leading scholars.

The seminars and their leaders currently are:

General Equilibrium Models—Kenneth J. Arrow, Harvard University and Gerard Debreu, University of California, Berkeley

Evaluation of Econometric Models—Philip Howrey, Saul Hymans, Harold Shapiro, University of Michigan and James Ramsey, Michigan State University

Comparison of Econometric Models—Lawrence R. Klein, University of Pennsylvania

Decision Rules and Uncertainty—Daniel L. McFadden, University of California, Berkeley

Distributed Lags and Time Series Analysis—Dale Jorgenson, Harvard University

Optimal Economic Growth and Natural Resources—Joseph E. Stiglitz, Stanford University

Bayesian Inference in Econometrics—Arnold Zellner, University of Chicago

Quantitative Studies in Industrial Organization—Edward Prescott, Carnegie-Mellon University

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

Decentralized Economic Planning and Programming—Roy Radner, University of California, Berkeley

Global Modeling—Bert Hickman, Stanford University and Michael Intriligator, University of California, Los Angeles

Seminar groups of the conference have produced more than 200 working papers, numerous articles published in professional journals and several books. These have been widely circulated and have made results of seminar discussions widely available.

For example, during 1974–1975 the *International Economic Review* published a series of papers entitled *Econometric Model Performance: Comparative Simulation Studies of Models of the U.S. Economy*. Over 125 pages in each of three issues, commencing in June 1974, were devoted to these papers, which are based on research and results developed by the Seminar

on Comparison of Econometric Models of the Conference. A paper summarizing some results from this seminar appeared in the Winter 1976 issue of *Annals of Economic and Social Measurement*. Policy simulation studies from this seminar were presented at a session of the December 1975 American Economic Association meetings and appear in the May 1976 *American Economic Review*. The above articles all will be reprinted in a special volume to be issued by the University of Pennsylvania Press. Also in 1975, the Seminar on Bayesian Inference in Econometrics published a compendium of papers presented at its meeting, *Studies in Bayesian Inference in Econometrics and Statistics*, S. Fienberg and A. Zellner, eds. (Amsterdam: North-Holland, 1975). Several other CEME seminar groups are planning compendium volumes.

Two seminars held NSF sponsored workshops in May and June 1975 in conjunction with their regular meetings. A session on commodity prices, energy, and inflation was held by the monetary and fiscal analysis group; and a seminar on energy related general research in microeconomics was held by the natural resources and economic growth group. The workshops were organized to examine existing knowledge on their respective topics and then to explore fruitful avenues of research. Rapporteur's reports on the seminar/workshops were issued in early 1976 and were widely distributed by the National Science Foundation.

Gary Fromm

Workshops on the Computer in Economic and Social Research

In 1975 six workshops on various topics were held. The first workshop, on estate multiplier estimates of personal wealth distribution, organized by Professor James D. Smith of Pennsylvania State College, was held on May 2–3, 1975, at the Urban Institute in Washington, D.C. About twenty economists participated in the workshop and the major topics considered were The IRS Estimates of Wealth, Regional State and County Wealth Distributions, National Balance Sheet, Federal Tax Policy and the Distribution of Wealth, and The Dynamics of Wealth Distribution.

On May 19–20, a workshop on various aspects of the economics of pensions was held at the Brookings Institution in Washington, D.C. The workshop included topics such as use of survey of newly entitled beneficiaries, social security registration of decisions, a framework for equity and social security benefits, social security and saving; international evidence, the effects of pensions and retirements on savings and consumption, and labor force participation consequences of social security. The workshop, attended by about thirty economists from the Social Security Administration and the academic community, was organized by Dr. Nelson McClung of the United States Treasury and Professor James Schulz of Brandeis University.

The third workshop in 1975, a large conference on stochastic control, was organized by Professor David Kendrick of the University of Texas at Austin and was held in Cambridge, Massachusetts, May 21–23. About sixty economists and engineers from various universities attended the two-day meeting. The main topics of discussion related to the use of control theory in large scale macroeconomic models, methods of efficient parameter estimations in control problems, identifications of econometric models, a sensitivity analysis of optimal stochastic control policies, uncertainty and optimal controls and control of nonlinear econometric systems with unknown parameters.

Time use and its economic consequences was the subject of the fourth workshop, organized by Thomas Juster of the University of Michigan. It took place at the Institute for Social Research in Ann Arbor, on May 28–29, 1975. The two-day workshop was attended by about forty economists from various governmental agencies and universities. The topics considered were quantitative and qualitative methodologies for estimating time use, measurement of output of use of time, family labor supply, childcare inputs and outputs, substitution of market goods for time, and transfer income effects on non-market time use.

The fifth workshop of 1975 was on micro-analytic modeling. The workshop, organized by Dr. Richard Wertheimer of the Urban Institute, was held at the Institute on May 29–30. About forty economists attended the meeting and the

topics discussed were micromodeling the non-household sector; dynamics of family structure; toward a microanalytic Monte Carlo simulation model of the Canadian household sector; alternative computer systems—benefits and costs for microsimulation applications; and impact of divorce on the distribution of earned and transfer income.

The subject matter of the sixth workshop was current research in the economics of education. The workshop was held October 2–4, 1975 at Princeton University and was organized by Paul Wachtel of New York University. The topics discussed were projecting demand for faculty; measurement and productivity in school rating programs; stratified labor markets; teachers and educational production; human capital model for LDC's; financing of schools, effects of GI bill; and simultaneous equation model of earnings functions.

This series of workshops has been made possible by a grant from the National Science Foundation.

M. Ishaq Nadiri

Latin American Computer Workshops

The topic considered by the sixth workshop in this series, held February 26–28, 1975, in São Paulo, Brazil was monetary correction or indexation. 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: to examine the Brazilian experience in indexation, and to discuss the "exportability" of the Brazilian experience to other countries, both developed and industrialized. Some of the topics discussed were an evaluation of Brazil's indexing system; indexation in the labor market; monetary correction of the exchange rates and bank deposits in Brazil; indexing and the fight against inflation; an analysis of Friedman's hypotheses on indexation; some considerations on costs of stabilization policies; and indexation

experiences in Canada, Israel, Argentina, Chile, Colombia, and Germany. The administrative implementation of these Brazilian experiences was analyzed. 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. The papers presented at the workshop will appear in *Explorations in Economic Research* (Volume 4, Number 1, Winter 1977).

This workshop was made possible by a grant from the IBM World Trade Corporation and the Ford Foundation.

Planning and short-term macroeconomic policy in Latin America was the topic of the seventh workshop which was held on the Isla Contadora, Panama, October 31–November 2, 1975. The conference, jointly sponsored by the Instituto Latinoamericano de Planificación Económica y Social (ILPES) in Santiago, Chile and the Ministerio de Planificación y Política Económica in Panama, was organized by James A. Hanson and Luis Eduardo Rosas of ILPES and Nicolás Ardito Barletta, Minister of Planning of Panama. About fifty economists from Latin American countries and the United States participated in the conference. The main purpose of the workshop was dual: to assemble an inventory of work on Latin American experiences with short-run macroeconomic tools, policies, and overall stabilization programs, and to identify the important questions in these areas and to indicate how short-run policymaking in Latin America can be improved and integrated with long-run development programs in these nations. Samples of topics discussed were the monetary approach to the balance of payments with empirical application to the case of Panama; econometric models of Chile and Nicaragua; a macroeconomic model of exchange rate policy and medium-term development; empirical inquiries on the short-run dynamics of output and prices; capacity utilization; employment stability and growth; the use of econometric models in Latin America; a model of external dependence of the Central American economies; the Phillips curve and the conflict between full employment and price stabilization in the Argentinian economy: 1964–1974; and stabilization experiences in Latin

America and the integration of short- and long-term policies. A select number of papers presented in this conference will appear both in Spanish and English this year.

This workshop has been made possible by a grant from the IBM World Trade Corporation and financial support from ILPES.

M. Ishaq Nadiri

Seasonal Analysis of Economic Time Series

Both from theoretical and practical 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. Especially during early 1976, public awareness of seasonal adjustment procedures has been heightened as a consequence of large changes in unemployment rates and differences between seasonally adjusted and unadjusted data. Also, in academic and government circles, there has been growing interest in providing better theoretical understanding of the sources and nature of seasonal variations in economic statistics.

The Bureau of the Census has recognized these needs and has sponsored an NBER/Census Conference on Seasonal Analysis of Economic Time Series, held in Washington, D.C., September 9–10, 1976.

A call for papers for the conference was issued during summer 1975 and resulted in the submission of abstracts from leading statisticians in the United States and abroad. Over 60 abstracts were submitted. From these, the steering committee for the conference, comprised of academic, business, and government experts on seasonal analysis, selected 12 papers for presentation, discussion, and possible publication in the conference proceedings.

The program for the conference is shown below. In addition, Julius Shiskin, long associated with the NBER and the Census Bureau, and currently Commissioner of Labor Statistics, the originator of the X-11 program now widely used for seasonal adjustment of economic data, delivered a keynote address.

- I. *Objectives and Framework of Seasonal Analysis*
 "Overview," S. Kallek, Assistant Director, Bureau of the Census
 Discussants: G. Fromm, National Bureau of Economic Research; L. Klein, University of Pennsylvania
 "Seasonality: Causation, Interpretation and Implications," C. W. Granger, University of California, San Diego
 Discussants: C. W. Sims, University of Minnesota; J. Tukey, Princeton University
- II. *Description and Analysis of Seasonal Adjustment Procedures in Use*
 "A Survey and Comparative Analysis of Various Methods of Seasonal Adjustment," J. Kuiper, Free University of Amsterdam
 Discussants: E. B. Dagum, Statistics Canada; J. P. Burman, Bank of England
- III. *Improvements and Special Problems in Procedures Currently in Use*
 "The Analysis of Single and Related Time Series into Components—Proposals for Improving X-11," R. R. BarOn, Ministry of Tourism, Jerusalem
 Discussants: J. F. Early, Bureau of Labor Statistics; H. V. Roberts, University of Chicago
 "Seasonal Adjustment when the Seasonal Component Behaves neither Purely Multiplicatively nor Purely Additively," James Durbin, University of London
 Discussants: N. Van Peski, Federal Reserve System; W. A. Spivey, University of Michigan
- IV. *New Methods for Analyzing Seasonal Problems*
 "Estimation of Structural Models of Seasonality," R. F. Engle, Massachusetts Institute of Technology
 Discussants: E. P. Howrey, University of Michigan; D. G. Watts, Queens University
 "Seasonal Adjustment when Both Deterministic and Stochastic Seasonality are Present," David A. Pierce, Federal Reserve System
 Discussants: L. Haugh, University of Vermont; W. E. Wecker, University of Chicago
- "Analysis and Modeling of Seasonal Time Series," G. C. Tiao, G.E.P. Box, and S. Hillmer, University of Wisconsin
 Discussants: G. A. Barnard, University of Essex; E. Parzen, State University of New York
- "The Graphical Analysis of Seasonality and Nonlinear Seasonal Adjustment," W. S. Cleveland, D. M. Dunn, and I. V. Terpenning, Bell Laboratories
 Discussants: P. Bloomfield, Princeton University; W. P. Cleveland, Duke University
- V. *Econometric Modeling and Seasonality*
 "Seasonal Adjustment and Multiple Time Series Analysis," K. F. Wallis, University of London
 Discussants: C. R. Nelson, University of Washington; T. J. Sargent, University of Minnesota
 "Time Series Analysis, Seasonality, and Econometric Models," C. Plosser, University of Chicago
 Discussants: G. C. Chow, Princeton University; R. E. Lombra, Federal Reserve System
- VI. *Aggregation and Seasonal Analysis*
 "The Temporal and Sectoral Aggregation of Seasonally Adjusted Time Series," J. Geweke, University of Wisconsin
 Discussants: M. C. Lovell, Wesleyan University; J. B. Taylor, Columbia University
 "Effects of Temporal Aggregation on Seasonal Time Series Models," W. W. S. Wei, Temple University
 Discussants: J. S. Chipman, University of Minnesota; P. M. Robinson, Harvard University
- VII. *General Discussion and Summary*
 "Retrospect and Prospect," A. Zellner, University of Chicago

Gary Fromm
Arnold Zellner

Conference on Natural Resources

This report summarizes a recent endeavor by a group of economists to extend and apply the principles of microeconomic theory to the discovery, extraction and utilization of natural resources. Sixteen papers were presented at the

conference at Stanford University and the National Bureau of Economic Research (West) on May 9–11, 1975 under the auspices of the NBER/NSF Conference on Mathematical Economics and Econometrics and the NSF Workshop on Energy Related General Research in Microeconomics. These presentations fell into four general categories:

Optimal Extraction of Natural Resources

Market Structure and Intertemporal Allocation

Special Problems of Exploration and Leasing

Economics of Renewable Resources

In each presentation, the investigator first established the socially-optimal policy for management of the scarce resources. The solution depends on the specification of the production process, the characteristics of the resource deposits, the accessibility and costs of information concerning uncertain future technologies and resource availability, the potential for recycling, and the choice of the objective function. Renewable natural resources require further consideration of the nature of the functions which model the natural growth of the biomass.

It is generally true that if the normal conditions (convexity, absence of externalities, etc.) are met, then a perfectly competitive, decentralized market equilibrium will support the optimal solution. However, natural resource markets demonstrate significant market imperfections. Several presentations describe the intertemporal paths of prices and extraction under conditions of monopoly, oligopoly, government regulation, common property problems, and incomplete securities markets in a world of uncertainty. Depending upon the assumptions in a specific situation, these imperfections shift the intertemporal extraction pattern either forward or backward from that of perfect competition, and there are circumstances where the pattern of extraction remains unchanged.

Special problems arise from the uncertainty in exploration and in the size of the reserves available. Government policies for risk sharing, information disclosure and bidding procedures have considerable impact on the efficient allocation of resources and on the distribution of revenues among the government and other mar-

ket participants.

Few of the presentations were concerned with issues of energy demand models, empirical estimation of demand and supply parameters, macroeconomic effects, or full analyses of specific policies. The focus was on the theoretical tools to model the conditions for socially-optimal management of natural resources and the underlying behavior in the resource markets. However, discussants did point to directions for productive future research in these areas, as well as in those which were the focus of the conference.

The overall conclusions of the conference are encouraging both to policy makers and applied economists who look to the basic foundations for insights to practical problems and to theoreticians who are looking for new mountains to climb. The response to current energy problems has been the development of theoretical principles to handle complicated issues of natural resource management. Yet there is still much to be done to refine the basic models; apply the theory developed in one area to another (fisheries to timber, for example); estimate many important parameters of the supply and demand models; and develop the basic formulations for many problems not yet solved.

A report on the conference summarizing the papers and discussion was issued in January 1976. Robert Solow and Joseph Stiglitz served as chairmen of the meeting and Perry D. Quick was the rapporteur. This summary is based on his report.

Gary Fromm
Joseph Stiglitz

Workshop on Commodity Prices, Energy, and Inflation

Macroeconomists have traditionally employed the strategy of confining their attention to the most highly aggregated variables in their attempts to explain macroeconomic developments. They have rarely concerned themselves with the structure of relative prices, which has been assigned as a topic for microeconomics research. As a result, through most of the post-war period, excessive aggregate demand and persistent wage-push have competed as ex-

planations of inflation. Recent events, however, seem to call for a reappraisal. There have been several important changes in relative prices which many people believe to have caused, or at least contributed significantly towards, the substantial world-wide inflation that has been experienced in the period 1972–1974. Along with the changes in the terms-of-trade and fluctuations in exchange rates, the most visible changes have occurred in the prices of petroleum and grains, but there has also been a sharp increase, followed by a sharp drop, in the prices of most raw materials. There have been changes in the relationship of demand and supply in particular markets as a result of policy, real scarcity, or the exercise of monopoly power by suppliers—changes which require an adjustment of relative prices to restore equilibrium. What role did these changes play in causing an increase in both the level and the rate of change of the average price level?

A workshop under the joint auspices of the NBER/NSF Conference on Mathematical Economics and Econometrics and the NSF Workshop on Energy-Related General Research in Microeconomics was convened May 8–9, 1975 at Yale University as a first step in assessing the extent to which relative price changes contribute to inflation in today's world. The intent was not to provide specific answers but to generate suggestions as to what areas in both the conceptual and empirical domains merit further explanations.

To understand the process by which commodity price changes cause inflation as well as the cost of such inflation and the optimal responses to it, a more disaggregated approach than is usually adopted in macroeconomics seems called for. The workshop participants sought to examine the aspects of structure and behavior of the various microeconomic links in the transmission process (commodity markets, business practices, labor markets, etc.) as well as the aggregate variables (aggregate demand, money supply, output, etc.). This was done in order to determine what we need to know with respect to measurement, theory, and policy.

A report which summarizes and elaborates upon discussions of the workshop was issued in May 1976. William C. Brainard and Richard N.

Cooper served as chairmen of the meeting. Robert Z. Lawrence was the rapporteur; this report is based on his summary.

William C. Brainard
Richard N. Cooper

Validation and Policy Application of Models

The need to explore model validation and public policy use issues and improve validation procedures and techniques, the extent of their application, and the potential utilization of models for public policy decisions has led to National Science Foundation sponsorship of workshops to define relevant issues and agendas for research. A workshop on validation and policy application of models was conducted in conjunction with two other activities—a seminar on comparison of econometric models held by the Conference on Econometrics and Mathematical Economics (CEME) and workshops of the Conference on the Interface between Computer Science and Econometric Model Building. The CEME seminar was held in St. Louis on June 12, 1975 and was followed by a workshop session. Some members of the group later met with other scholars in Denver, Colorado on June 13th and they attended the Workshop on Model Formulation, Validation and Improvement in Vail, Colorado on June 14–15, 1975. A report on these sessions was issued in Fall 1976.

Gary Fromm

Public Forum on Economic Issues

Concern about the public's isolation from consideration of economic issues 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 economic problems. After careful consideration of alternative media, contents, participants, and formats, it was decided that public television was an ideal medium to provide nonpartisan, balanced examinations of selected issues and the policy options that might be used to alleviate existing and potential economic difficulties.

The Forum was organized by the National Economists Club Educational Foundation and has been supported by grants from the National Science Foundation and various private founda-

tions and corporations. NBER staff serve as members of the advisory board and panels and as program participants.

Three programs were produced and shown during late 1974 over the Public Broadcasting System's (PBS) educational television network. These programs, on inflation, the high cost of healing, and the quality of life were aired by more than 212 stations and seen by an estimated 13–15 million viewers. During 1975 there were additional airings and cassettes were available to schools and other organizations through the PBS program library.

Efforts are underway to raise funds for further programs.

Gary Fromm

Research Fellowships

The National Bureau's research fellowships 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 and they have access to Bureau facilities and associate with members of the research staff who are experienced in empirical research and who are generally familiar with the types of problems being investigated. The nature of a fellow's research interests usually determines which of the National Bureau offices is most suitable for his work.

The program now has two phases. One, which dates back to 1930, is the awarding of Faculty Research Fellowships to scholars selected primarily from universities in the United States. The Alfred P. Sloan Foundation is currently providing financial assistance for some of these fellowships. The second phase, begun in 1972, with the support of the Rockefeller Foundation, brings Foreign Research Fellows from universities in Africa, Asia, and Latin America to the Bureau.

Faculty Research Fellows for 1975–1976 were Donald O. Parsons of Ohio State University and Daniel L. Rubinfeld of the University of Michigan. Parsons, who was designated as the Harry Scherman Research Fellow for the year, was at the Center for the Economic Analysis of Human Behavior and Social Institutions at NBER-West. His research included a study of the production

and transfer of wealth within the family and also an investigation of layoff decisions and unemployment of experienced workers. Rubinfeld, at the Cambridge office, was engaged in investigations of the relationships between zoning and the fiscal operations of local governments, property values and benefits of environmental improvements, and an empirical study of voting in school elections.

For 1976–1977 the Faculty Research Fellows are Daniel A. Graham of Duke University, Cheng Hsiao of the University of California, Berkeley, and J. Huston McCulloch of Boston College. Graham will be at the New York office; his research interest is in developing an empirically tractable method for valuing human life through the value of life concept reflected in "irreplaceable commodities," and comparing this method with other measures, such as human capital. Hsiao will be at the Cambridge office pursuing his interest in econometric methods for models in which insufficient information precludes application of previously developed techniques. McCulloch, the new Harry Scherman Research Fellow, will be engaged in a study of the maturity structure of the assets and liabilities of financial intermediaries and will be attached to NBER-West in Palo Alto.

Foreign Research Fellows in 1975–1976 were Romeo M. Bautista, University of the Philippines and Patricio Meller, Catholic University of Chile, both of whom were at the New York office, and Oey Astra Meesook of Thammasat University, Bangkok, who was at Palo Alto. Bautista's research was on adjustments in trade in less developed countries to exchange rate changes; Meller's was on efficiency frontiers for industrial establishments in Chile, trade strategies and employment in Chile, and industrial concentration in Latin America; Meesook's was on income distribution in Thailand. In July 1976, Narongchai Akrasanee, also of Thammasat University, came to the New York office for the 1976–1977 fellowship period to pursue his research interests in trade and industrialization in Thailand and economic relations among Pacific Basin countries.

Reports by fellows on their work at the National Bureau during 1975–1976 are included in the staff progress reports.

Douglas H. Eldridge