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Staff Reports on
Research Under Way

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1. MEASUREMENT OF ECONOMIC AND SOCIAL PERFORMANCE

Introduction

This project, supported by the National Science Foundation, is involved in extending the national economic accounts to provide better measurements of economic and social performance and a framework for the integration of both macro and micro economic and social data. At the macro level, balance sheets and wealth, nonmarket activities, the environmental factors, and total income measurement (including revaluations) are being introduced into the national accounts in order to make them more comprehensive. At the micro level, data sets for households, enterprises, and governments are being developed in a form which will fit into and be aligned with the sectors established for macroeconomic data. Such microdata sets 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 system of national accounts—Richard Ruggles and Charlotte Boschan
   b. National wealth and balance sheets—Raymond W. Goldsmith
   c. Total income measurement—Robert Eisner
   d. National accounting and the environment—Henry M. Peskin and Leonard P. Gianessi
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

   Richard Ruggles

The Extended System of National Accounts

The current system of United States national income accounts is being extended to include nonmarket activity and balance sheet information at a subsector level, for which microdata sets are being developed. At the macro level the national income data of the Bureau of Economic Analysis and the flow-of-funds data of the Federal Reserve Board are being augmented with data provided by John W. Kendrick, Raymond W. Goldsmith, Henry M. Peskin, and Robert Eisner. The nonmarket activity is being separated sharply from market transactions data in order to obtain a better understanding of the operation of both market and nonmarket activities and their interrelationship. In · some cases microdata sets for households are being used to generate estimates of nonmarket activity.

A simple version of NEAT (computerized system for national economic accounting tables), the project's set of programs to facilitate the designing and redesigning of economic accounting structures, has been completed. It is operational in the sense that data can be extracted from our various collections of basic data, new relationships can be specified, and tabular output can be

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designed—all in an interactive mode. Some new modules have been programmed but are not yet operational (e.g., providing automatic footnotes which may be attached to entire time series or individual observations, facilitating interactive revision, and updating of time series); others are in the programming stage (e.g., providing more elegant tables, cross-referencing relationships, and providing period averages); still others are in the planning stage (e.g., compiling perpetual inventories, making programs easier to use).

The major data bases available to the system include the NBER time series data bank, the FRB flow-of-funds tape, most of the national income and product accounts of the Bureau of Economic Analysis, and some of BEA's fixed capital series as published in its "Fixed Nonresidential Business and Residential Capital in the United States, 1925–75." We are in the process of adding and revising the last of the national income and product accounts. We are also setting up series titles to go with the short code names. These titles are necessary in order to identify individual series, and they will automatically be used as stubs in the tables produced by NEAT, unless specific stubs are provided by the user. Also, since data collections are incorporated into the project's data base with as little change in original code names as possible, and since some series appear several times with several different codes, we need a list of equivalent codes, so that the system knows that NBER's series called GNP is the same as FRB's 86901005 and BEA's Table 1.1 line 1 (or 010101). As always, the initial setting up of specifications and other tables takes time but will be very helpful later when the system is used more intensively.

Richard Ruggles
Charlotte Boschan

National and Sectoral Balance Sheets

The goal of this project is to develop annual balance sheets for the nation and for several dozen sectors and subsectors for the period 1947 through 1975. Work so far has been concentrated on tangible assets, and this part of the project is expected to be completed shortly. Preparatory work has been done on financial assets, which will be the center of attention during the coming months.

Raymond W. Goldsmith

Total Income Measurement

Revisions have been completed on "Capital Gains and Income: Real Changes in the Value of Capital in the United States, 1946–75," which was presented to the Toronto meetings of the Conference on Research in Income and Wealth in October 1976.

The paper presents capital gains or "net revaluations" as the difference between market value or replacement cost, as estimated from price deflators for the relevant item or category of capital, and the money value of capital necessary to keep its real value intact. Capital gains or net revaluations are thus increases in the value of existing capital over and above the amount corresponding to general inflation.

Net revaluations are estimated by sector—household, farm and noncorporate nonfarm, corporate nonfinancial, all financial, and government—for tangible assets and financial assets and liabilities, item by item, and for total net worth. Estimates of total capital accumulation and revaluations are presented for both human and tangible nonhuman capital.

Net revaluations or capital gains turn out on balance to be substantially positive, despite considerable fluctuation, particularly in certain financial assets and liabilities. Capital gains over a thirty-year period, even after allowance for general inflation effects, have not been completely offset by capital losses.

On tangible assets alone, mean net revaluations were approximately $28 billion. Mean tangible net investment aside from revaluations was $68 billion. These magnitudes relate to all tangible nonhuman capital in government and households and

in business, and include both land and reproducible assets. By comparison, mean net private domestic investment in the conventional income and product accounts was $40 billion over these years. Total tangible capital accumulation from 1946 through 1975 measured $2,870 billion. Total net private domestic investment reported by the Bureau of Economic Analysis was $1,197 billion.

In 1969 dollars and including all household assets, mean household non-human capital accumulation came to $64 billion for the period from 1946 to 1969; $19 billion stemmed from net revaluations. Mean human capital formation for this period was estimated at $103 billion, of which $8 billion related to net revaluations.

There were major capital gains by government, substantial gains for nonfinancial business, both corporate and noncorporate, and some losses on balance in the financial sectors. Households (including personal trusts and nonprofit institutions) were on balance gainers, with substantial differences, however, by category of assets and liabilities. Owners of land and owners of homes (because of the gains on mortgage debt liabilities), owners of unincorporated business, and, until recently, owners of corporate equity tended to do well. Households not relatively well situated in terms of these kinds of investments tended to be losers because of the substantial negative net revaluations on currency, demand and time deposits, and life insurance and pension funds.

Our major sources included published and unpublished material from the Flow of Funds Section of the Federal Reserve Board, the Bureau of Economic Analysis of the Department of Commerce, and John Kendrick's *The Formation and Stocks of Total Capital* (NBER, 1976). An appendix describing sources and methods in detail has been prepared by Marsha McClure and Rene Moreno.

Work in completing and revising estimates for the total income system of accounts is proceeding. A paper embodying the results will be presented to the meeting of the International Association for Research in Income and Wealth in York, England, in August 1977. Also, John Graham and Roy Webb will be presenting an updated version of their "Present-Value Estimates of Human Capital Stocks" (described in last year's Annual Report).

Graham plans to complete his study, initiated last year, on the determinants and composition of total household saving. He defines saving as change in net worth and includes not only the accumulation of all types of financial assets, but also of tangible assets such as household durables and residential structures, and intangible human capital. His theoretical framework stresses interrelationships of the different types of asset accumulation, with particular emphasis upon the human capital decision. The theory generates hypotheses concerning the timing, magnitude, and mix of asset accumulation which are subjected to empirical verification using a cross-sectional panel study, "Consumer Durables and Installment Debt," provided by the Michigan Survey Research Center.

Webb is continuing his study of costs of inflation, including those stemming from related increases in the variation of relative prices and in the time devoted by buyers to market search. Theoretical analysis suggests, however, that the costs are not related to steady inflation but to changes in the rate of inflation. Preliminary empirical work supports this suggestion. An interesting by-product of Webb's analysis is the indication that in markets with imperfect information and random shocks to supply and demand, sellers may have kinked demand curves, even with many actively competing sellers, quite aside from an oligopolist's concern with reactions by rivals to price changes.

Ronald Rost has estimated production functions for two-digit industries and more aggregated sectors of the U.S. economy which suggest that the slowdown in labor productivity growth can be attributed in part to the replacement of capacity-expanding investment by pollution abatement investment. Currently he is estimating the social cost of the stock of pollution abatement

capital as the present value of the conventionally defined output that was not produced because of the resultant slower growth of productivity. Available data permit such an estimate over the period 1967–1976, and will indicate the extent to which the social cost of pollution abatement capital has deviated from its market value. In any analysis of the net benefit resulting from pollution abatement investments, this social cost must of course be weighed against the corresponding social benefits.

Augustine Fosu is working on estimates of human capital that will reflect the present value of expected future earnings in the form of supplements or fringe benefits as well as wages and salaries. It would thus relate to all of the expected marginal product of labor. Aggregative data on fringe benefits are available at the firm, establishment, or industry level but not for individuals categorized by personal characteristics such as age and sex. Fosu hypothesizes, however, that employers minimize their labor costs by feasible combinations of fringe benefits and wages and salaries which fit the preferences of their employees. Hence, since employee characteristics differ from industry to industry, fringe benefits will differ as well.

Fosu is utilizing Bureau of Labor Statistics tapes containing data on fringe benefits, direct earnings, hours, and other details of employment by establishment for 1971. He also has census data on individual characteristics, which can be mapped onto industries. The relationship between fringe benefits, earnings, age, and sex may thus be estimated. Further, by filtering out industry effects unrelated to employee preferences, it should be possible to establish a relationship between individual characteristics and preferences for fringe benefits.

Since fringe benefits constitute a substantial portion of total labor compensation (19.6 percent of wages and salaries in 1975, according to estimates of the U.S. Chamber of Commerce), their consideration may prove of substantial importance in comprehensive estimates of human capital

as well as in various aspects of labor market behavior.

Robert Eisner

National Accounting and the Environment

The purpose of this project is to include imputed measures of the services of environmental assets and associated pollution damage in an expanded national accounts framework.

Major emphasis during the past year has been placed on the development of data that will permit estimation of the dollar value of water pollution damage in geographical detail. In this connection a new data set has been developed that permits a linkage of industrial and household activity at the county level with the physical characteristics of those water bodies that constitute the county's drainage system.

Several research papers which use the environmental accounts as a data base have been completed or are nearing completion. One is a study of alternative estimates of industrial waste generation and discharge. In that paper it was shown that the source of often vast differences in the estimates of different investigators was a combination of different implicit assumptions and different interpretations of official government data.

A second study is a theoretical and empirical investigation of the effects of extending the environmental asset accounting system to other nonmarket goods and services, particularly in-kind governmental subsidies. This paper (being prepared with the assistance of Janice Peskin of the U.S. Department of Health, Education and Welfare) is to be presented at the fifteenth conference of the International Association for Research in Income and Wealth in York, England, August 1977.

A third paper contains analyses of per family net benefits (benefits minus costs) of the Clean Air Act of 1970 by region, income class, and race. The principal result is that net benefits are positive for only about one-third of the population, generally those liv-

ing in urban areas and having low incomes, large families, and relatively low per capita automobile ownership. However, the average gain of a family with positive net benefits far exceeds the average loss of a family with negative net benefits.

Finally, a report on the project was presented at a conference on environmental indicators held by the International Institute for Environment and Society in West Berlin, Germany, December 1976.

Henry M. Peskin
Leonard P. Gianessi

The Construction of Household Balance Sheets

Work on the construction of household balance sheets was divided into two phases. The first involved the construction of a micro data base containing demographic data, consumer durable holdings, and income flow data from financial and other income-earning assets for households. The data base was formed by a statistical match of the 15 percent and 5 percent 1/1000 Public Use Samples of 1970 (the two samples differ in their inventory of consumer durables) and the 1969 Internal Revenue Service (IRS) Tax Model. This phase has been completed. Estimates of income flow totals made from this data base agree very closely with corresponding entries in the National Income and Product Accounts for 1969.

The second phase involves the imputation of values to assets and liabilities of households. The value of owner-occupied housing and the holdings of consumer durables such as automobiles and television sets are provided in the Public Use Samples. To value these durables, we ran regressions, using the 1961 Bureau of Labor Statistics Consumer Expenditure Survey, of the purchase price of durables on family income and demographic characteristics of the family. Moreover, we computed the likelihood of purchase of each durable by income and demographic characteristic. Using a random error generator, we will impute to each household the current value of

each durable held and reconcile these estimates with specially obtained Bureau of Economic Analysis estimates. Income flows such as interest, dividends, farm income, pension income, and small-business profit (or loss) are provided in the IRS file. These flows will be capitalized using average yields for each asset (and each liability such as mortgages and consumer debt) and reconciled with flow of funds estimates. This work is currently in progress.

A Reliability Test of the Statistical Matching Procedure

Since an important question in our construction of household balance sheets is the reliability of the matching technique, we have designed a test of its reliability. The central problem is to determine how closely the joint distribution of actual and imputed variables corresponds to the actual joint distribution. In most cases the actual joint distribution is unknown. However, in the special case of the two Public Use Samples, the actual joint distributions of most variables are known. By regressing imputed variables on actual ones and actual variables on actual ones and comparing the regression results by using a Chow test, we can then determine whether the joint distributions are statistically different. Preliminary results suggest little statistical difference between the imputed joint distributions and the actual ones.

Determinants of Earnings Inequality

A paper entitled "Age, Education, and Occupational Earnings Inequality" was presented at the Econometric Society meetings in Atlantic City in September 1976. Using data from the 1960 and 1970 Census Public Use Sample, we arrived at four major conclusions: (1) The earnings function—the relation between earnings, schooling, experience, and demographic characteristics—varied considerably among occupational groups. (2) The earnings function shifted between 1960 and 1970 because there were demographic shifts and a stable occupational distribution. (3) The earnings function was not independent of the occupa-

tional structure. (4) The results broadly supported the hypothesis that the size distribution of earnings was generated by the occupational (and by implication the industrial) structure of the economy, though individual earnings were associated with individual characteristics. This paper is currently being revised.

Screening and Earnings

A draft of a paper, "Educational Screening and Occupational Earnings," was recently completed and the results presented at a seminar at the Palo Alto office of the National Bureau. Using data from the 1970 Public Use Sample, we compared schooling and earnings for self-employed and salaried members of thirty-four occupations. In occupations with customer contact, we predicted that self-employed workers would acquire more schooling than salaried workers to signal prospective clients of their productive capability. In other occupations, we predicted that since that need to signal would not exist, self-employed workers would acquire less schooling than salaried workers. The results generally supported our hypotheses.

Life-Cycle Expenditure Patterns

A draft of a paper, "The Life-Cyclers," was recently completed. Using data from the 1961 Consumer Expenditure Survey, we examined life-cycle earning and expenditure patterns by demographic group to determine whether they conformed to the widely accepted model of dissaving in early years followed by saving in the middle years and dissaving in the years after retirement. We found that this pattern held for white urban families headed by a married, white-collar man. For other groups, the pattern deviated considerably, with some showing no saving at all over the life cycle.

Edward Wolff

Lifetime Income Patterns of Individuals

In this study time series of lifetime incomes were constructed for several birth cohorts of men and women, covering extended periods of their adult lives since World War II. It is believed that this data set and the analyses undertaken with them provide useful perspectives on a variety of income distribution questions.

This progress statement outlines the main parts which are now being processed for inclusion in our final report on the lifetime income subproject. In the introduction to the final report, this subproject is related to the general project on the Measurement of Economic and Social Performance. The objective of the general project is to improve the data base for the national economic accounts to permit a wider range of analyses of welfare problems, of changes in economic growth, and of income distribution. The purpose of the lifetime income subproject also is to improve the data base for analysis of income distribution, particularly analysis of changes over time rather than of differences at one point in time.

The first main part is a historical view of the average age-income profile for U.S. men for the past twenty-five to thirty years. Averages are presented of both cross-sectional differences at a point in time and cohort changes over time. The difference between these patterns provides a basis for an estimate of the contribution of economy-wide changes to the growth of lifetime income for representative cohorts. Economy-wide changes include both the general rise in real wage rates resulting from productivity gains and changes in the distribution of jobs among the different wage rate brackets. The growth in output per man-hour of approximately 3 percent per year in the period from 1947 to 1972 seems to account for most of the difference between cohort and cross-sectional patterns. The report contains discussions of a number of methodological issues associated with such comparisons as well as a discussion of problems and promises of cohort and longitudinal data generally.

The second major set of results relates to the analysis of differences among groups in the level and time shape of lifetime income. The differences are analyzed both within

and among cohorts. Intercohort differences are presented by comparing the time shape of income of older and younger cohorts at comparable stages of life. For most of the postwar period, except for short periods of recession, the time shape, measured as a rate of change with age, appears to have remained fairly uniform for white men. For other groups and more recent periods we are still working through numerous data problems to evaluate evidence of changes over time in the shape of lifetime income patterns. This aspect is particularly important to those who entered the labor force during the last decade or so—the so-called baby boom cohorts.

Intracohort differences are also presented in the report. The general pattern of increase in inequality of income for a given cohort as it ages appears to be true for white men but not for nonwhites or women.

A third major part of the study is concerned with lifetime income patterns by source of income. An exploration is made of the different time shapes of earnings, property income, and other income and their relative contributions to total lifetime income.

A final section contains a methodological discussion of cohort analysis—its problems and promises and avenues for major data improvement both in federal and private survey statistics.

Milton Moss

Lifetime Indicators of Well-Being

Research on Goals Accounting, a project funded by the National Science Foundation, is to be carried out by a consortium which includes the National Planning Association (coordinator), the Carnegie-Mellon University, the Conference Board, the University of Michigan, the University of Texas at Austin, and the National Bureau.

A subproject, Lifetime Indicators of Well-Being, is to be undertaken at NBER. A one-year feasibility effort by the consortium is provided for by NSF. The purpose of this subproject is to extend the lifetime approach beyond lifetime income (an ongoing NBER project) to other domains of life such as lifetime health and employment. In the one-year feasibility study by the consortium, however, the extension is confined to lifetime employment or labor force participation. Should the project be funded on a longer-term basis, lifetime indicators would be developed for other domains of life as well. Our long-term aim with the use of lifetime indicators is to map social changes in such a way as to be able to compare changes in well-being of successive generations in their major "walks of life."

Lifetime employment or labor force participation was chosen for the one-year feasibility phase of the project for three reasons: First, this important domain of life could provide a good illustration of a lifetime perspective to the study of social change. There are particularly pronounced life-cycle patterns in labor force participation, and these patterns are undergoing dramatic changes.

The second reason is that the consortium plans to make a modest effort in the first year to analyze a significant policy area—a segment of the Social Security system—in order to provide an example of a policy application of the goals-accounting project. Changes in the size and composition of the labor force resulting from changes in the age distribution of the population and in age-specific rates of labor force participation and their effects on the "dependency ratio" are central questions concerning the future of the system.

A third reason is that future growth of the labor force is one of the major resource constraints which must be taken into account in assessing the capabilities of the United States for improving national well-being. Changes in the manner in which household members apportion their time between market work and other activities over their lifetimes have important implications for the size and composition of the labor force, the economy's productivity and rate of growth, and the distribution of income.

Milton Moss

Enterprise Microdata Sets

The purpose of this project has been to create new sets of data for enterprises by combining information from a variety of public and private sources. One set is to be a historical record for firms, including those that have disappeared by merger or bankruptcy, and the other is to be a cross section, for a period in about 1972, of firms and their individual establishments.

Our fullest historical record for firms will cover about three hundred companies. For these we have combined the standard types of financial accounts, such as balance sheets and income statements, with a variety of detailed data on the investment process, including breakdowns of capital expenditure by type and extensive information about research and development expenditures.

For a larger group of some two to three thousand companies we have not expanded on the financial statements but have added information on hundreds of companies no longer in existence. The result is a data set that covers considerably more of the corporate universe of, say, 1950 than a current financial data tape such as Standard and Poor's Compustat. Our restoration of defunct companies is not complete, but does cover most of the disappearances of the late 1960s and early 1970s and indicates that a more thorough job could be done with additional time and resources.

A greater part of our effort has gone into the construction of microdata sets for establishments as of about 1972. These are to produce both a geographical and a company cross section for that year which will contain a wide variety of characteristics that can only be derived from information about the establishments of each company.

· For the most part, the establishment data cover manufacturing. The basic original data sets we use are a Dun & Bradstreet file of well over 350,000 establishments and an Economic Information Systems (EIS) file of over 100,000 establishments. In both cases the entries are identified by parent company, location (county, address, and zip code), and industry, and include a count of the number of employees. A third original data source, an employment characteristics file of about 140,000 establishments in 1970, reports the composition of employment in each establishment by occupation, race, and sex.

Of the three basic data sets, the D&B is most complete. The manufacturing employment reported is about 99 percent of the Census of Manufactures total for 1972 in states other than Alaska and Hawaii, while that in the EIS tape is about 86 percent and in the employment characteristics tape, considerably less. In individual states, the D&B totals fall within 10 percent of the Census aggregates in 36 out of 49 cases and are more than 15 percent away in only two. However, the cross-classification by state and industry indicates much larger discrepancies with Census figures, about a third diverging by 20 percent or more. Although we can already produce a breakdown of employment by detailed industry by state and county we hope to improve this breakdown by using some of the EIS data, which seem to be more exact about industry classifications.

The identification of ownership links between enterprises and establishments is proving to be a more difficult problem than the geographical distributions. Although all three tapes purport to show such links we find that there are many discrepancies and omissions. We are working to improve all three data sets in this respect but we are not sure that we will be able to produce a unified, complete data set. We will therefore begin by developing the company-establishment links for the 400 firms with the most complete time series data, go on to do the same with all of the firms for which we have financial data, and only then try to encompass large numbers of the other firms.

Since one of the main plans for the current year is to incorporate the employment characteristics data into our larger data collection we carried out an experiment on a sample of firms to merge these data with one of the other establishment data sets and with information outside our system. The

sample consisted of 130 companies in nine industries, their 794 establishments in the primary industries of these companies, and the counties in which the establishments were located. The work on the sample confirmed our fears that the links between company and plant on the employment characteristics tape were seriously incomplete. However, we were encouraged to learn that between 70 and 90 percent of the plants on the EIS tape could be identified on the employment characteristics tape and that about 75 percent of the employment reported in the Census of Manufactures was covered. We now have, for the companies in the sample, the combination of EIS and employment characteristics data on each covered establishment; the race, sex, and occupational distribution of each county in which a plant is located; and financial data for the firm as a whole. While we do not yet see a way of merging the whole employment characteristics file with the others, we are now optimistic about its usefulness in describing labor force composition for fairly large samples of firms.

Stanley Lewis carried out the detailed matching and computer manipulation of files for this study.

Michael Gort
Robert E. Lipsey

Government Microdata Sets

This project has been directed toward producing geographically disaggregated estimates of the public-sector activity included in the national income and product accounts. Detailed revenue and expenditure accounts for state and local governments have been prepared which are consistent with the aggregate accounting structure. Less detailed accounts were prepared for the composition of and changes in public debt. The accounting structure has been applied to the creation of two data sets—one providing income and product account information separately for each of the fifty states and the other providing similar estimates for "county aggregates" of local governments. The county aggregates include a separate revenue, expenditure, and debt account for each of the 3,118 counties in the United States by aggregating (and netting where appropriate) the activities of all local governments within each county boundary.

The results of this analysis have been subjected to a number of consistency checks and compared with available aggregate data sources on public-sector activity. In general, it appears that the accounting structure is quite satisfactory and is in close agreement with the aggregate public-sector accounts.

A detailed working paper outlining the sources, methodology, and assumptions of the analysis has been prepared, together with the results of a series of internal and external tests for consistency. Data sets for the benchmark year of 1972 and the supporting documentation are available to interested users on request.

Currently under way is a further disaggregation of these accounts for urban counties. The extended data set will present separate estimates for each central city and for the remainder of each metropolitan county. It is anticipated that these additional estimates will be available before the end of 1977.

John M. Quigley

2. PRICES AND PRODUCTIVITY

Introduction

While prices and productivity have traditionally been major foci of research at the National Bureau, recent developments, particularly inflation, have served to elevate general interest in these subjects. Work under way, as well as new initiatives, have been complemented both by research on international aspects of inflation and by two

Income and Wealth conferences, one on price behavior and the other on productivity, cited elsewhere in this report.

The research program covers both measurement and analysis. A major analytical focus is on the development of a model of the economy by stage of process, which traces and quantifies the propagation of inflation domestically. A paper describing the model was presented by Joel Popkin at the 1976 meetings of the American Economic Association. As part of this project, Avram Kisselgoff continues his analysis of how changes in crude oil prices are transmitted to the prices of refined petroleum products purchased by end-users. A new project has been undertaken which has as its objective the analysis of productivity change by stage-of-process sector, of how such change affects sector prices, and of the routes by which such effects ultimately impact on the overall inflation rate. M. Ishaq Nadiri is examining the impact of expenditures for research and development on productivity at the firm level. Some pilot work is also under way by Wayne Vroman on the behavior of wage rates.

The episode in the early 1970s of double-digit inflation underscored the need to improve the measurement of prices and the variables that determine them. Richard Ruggles has completed a review and evaluation of the U.S. wholesale price index and its components, a price index system of major importance as an early indicator of changes in the overall rate of inflation and as a deflator of nominal output on an industry basis. Robert J. Gordon has been studying the components of the wholesale price index covering producers' durable goods and other price series. He is currently completing his manuscript on the measurement of durable goods prices. The problem of measuring inventory change, an important element in short-run changes in economic activity and in price determination, has been exacerbated by high rates of inflation. A study of the measurement of business inventories and recommendations for its improvement are being prepared for submission this year by Murray Foss, Gary Fromm, and Irving Rottenberg. Robert Eisner's manuscript, "Factors in Business Investment," is scheduled for review by the Board of Directors prior to publication.

Joel Popkin

Inflation Study

During the year work neared completion on the development of an integrated model of final and intermediate demand by stage of process. The model, which will soon undergo thorough testing, will be used to analyze the sources of U.S. inflation, 1965–1974. The project has been funded by the National Science Foundation.

In the model, the final demand and intermediate commodity sectors interact in the following way: For any grouping of final goods—consumer home goods, for example—their prices, expected demand, and any inventory disequilibrium determine orders placed with manufacturers. The levels of manufacturers' production, finished goods inventories, and unfilled orders are then determined by using models based on linear decision rules for the firm. These decisions in turn affect capacity utilization rates and the change in unfilled orders and finished goods inventories. These three, together with hourly labor costs and materials input prices, enter the equation for manufacturers' prices. This process, which is depicted in Figure 2.1, is repeated backward through the stages of process.

Work on the subset of price equations is most advanced. Equations have been estimated on the basis of several assumptions about price equations for each of the sixteen manufacturing sectors and five retail trade sectors. When the results for the twenty-one sectors are viewed as a whole, they appear to support the general conclusion that the influence of demand on the relationship of

FIGURE 2.1

INTEGRATED MODEL OF FINAL AND INTERMEDIATE DEMAND BY STAGE OF PROCESS
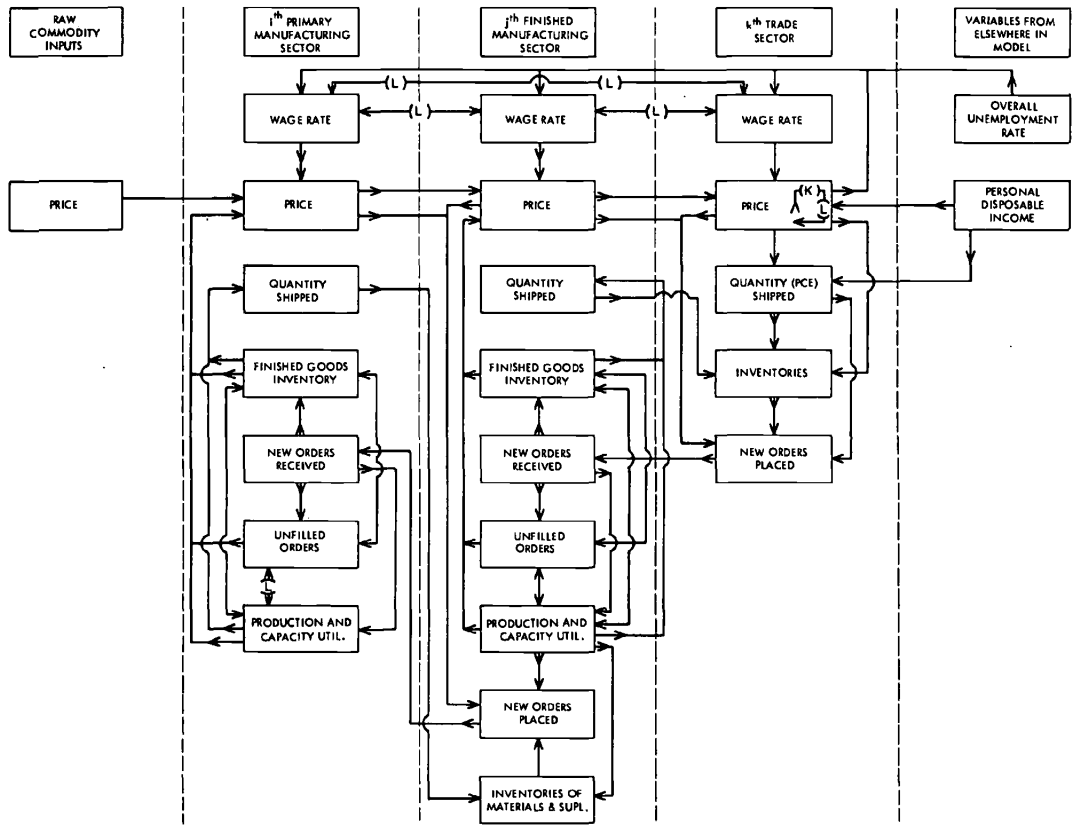
Note: K signifies intersectoral influences within the trade bloc, and L indicates a lagged effect.

output to input prices takes place in the primary and semifinished goods industries, rather than in the finished-goods-producing and -distributing industries. This is particularly apparent for consumer goods. The results for the manufacturing sectors have been used in simulations to assess the impact on final prices of changes in wages and prices at earlier stages of process. This work has been supported by the Council on Wage and Price Stability.

A related, newly initiated project, supported by the National Science Foundation, concerns the relationship between productivity change and price change. The main objective of this research is to provide information needed to determine the sectors of the U.S. economy in which productivity improvement—arising with respect to

capital, labor, or materials—can be expected to result in the largest reductions in overall inflationary pressures.

The study is designed to shed light on the following questions: (1) What has been the measured change in the productivity of labor, of capital, and of materials in each stage-of-process sector from 1954 to 1975? (2) What has been the change in total factor productivity in each stage-of-process sector during the same period? (3) How have the changes in individual and total factor productivity in each sector corresponded to the impact that price changes in each sector have had on the price of final output? (4) To what extent, in the long run, has productivity change been reflected in price behavior in each sector and in the overall rate of inflation? The analysis will be done for

thirty-one private commodity- and service-producing sectors in the intermediate sector of the overall model described above.

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, described in last year's reports, of the determinants of investment, employment, and R&D has been developed and estimated. In estimating the model we have compiled the necessary data for 114 companies for the period 1964–1974. 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 was first fitted to the data for a subsample of 62 firms for the period 1965–1972, and the results supported the specifications of the model. A paper based on these results will be published in *New Developments in Productivity Measurement,* a volume of the Conference on Research in Income and Wealth. A larger manuscript describing in some detail the formulation of the model, the nature of the data, and the results of several specifications of the basic model, using the data on a sample of 114 firms, has also been completed. The main findings of our research 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. The research and development activities of the firm, like its demand for labor and capital, are influenced significantly by both output and relative input prices and by degree of capacity utilization.
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 affected significantly by their research and development expenditures, and labor productivity is significantly affected by capital accumulation.
5. Demand for each of the three inputs is 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.
6. The model is a good predictor of investment, employment, and R&D investment of individual firms. The parameters estimated from the pooled cross-sectional time series of the firms in the sample are used to generate predicted values of the dependent variables for each individual firm.

M. Ishaq Nadiri

The Wholesale Price Index

On the basis of comments of January 15, 1977, of an NBER advisory committee and additional comments provided by the Bureau of Labor Statistics, a draft of "The Review and Evaluation of .the Wholesale Price Index" was revised and given to the Council on Wage and Price Stability on March 15, 1977.

In the report it was concluded that the wholesale price index and the price data on which it is based are widely used and constitute a centrally important set of economic data. It was further concluded, however, that there are a number of major deficiencies which seriously impair the usefulness of the index. These are as follows:

1. The scope and coverage of the wholesale price index is inadequate for the uses made of it. The index currently covers agriculture, mining, and manufacturing prices. Most of the agricultural prices are

provided by the Department of Agriculture, and only about 25 percent of the four-digit SIC industries (constituting about half of total production) are adequately covered. The wholesale price index should be changed to be an industrial-sector price index covering only mining and manufacturing, and the collection of price data should be expanded to provide adequate coverage.

2. The classification system used for the wholesale price index is inappropriate. Rather than using a unique classification system for the wholesale price index which can only be transformed into the Standard Industrial Classification System with some difficulty and ambiguity, the Bureau of Labor Statistics (a) should move directly to the SIC System and (b) should develop a stage-of-processing sectoring based on input-output relationships.

3. The lack of integration between wholesale price data and other economic data, such as production, employment, orders, and inventories, impairs the analytical usefulness of these related bodies of data published by the various agencies in the federal statistics system. A systematic effort is needed to integrate these various series at the micro and aggregate level.

4. The present intermingling of shipment and order prices results in data which are difficult to interpret. As is shown in the table below, which is for mid-1976 and is based on a 1-in-14 sample drawn from WPI observations, some of the price data refer to order prices and some to shipment prices and the order-to-shipment lags vary considerably:

This suggests that the Bureau of Labor Statistics needs to give greater attention to ascertaining whether it is collecting order prices or shipment prices and additional information is also needed on order-to-shipment lags. It is not correct to deflate current shipment values by current order prices and, conversely, shipment prices may not serve as early warnings of price inflation if there is a long order-to-shipment lag and no escalation provision.

5. In some instances wholesale price data fail to capture changes in transaction prices. As a result in some cases the wholesale price index does not show the softening of price increases which may occur in a period of oversupply or declining economic activity and, conversely, it may underestimate the increase in price with increasing economic activity and tightening up of supplies. Although no single source of information can be relied upon to provide transaction prices, monitoring a number of different types of price information (i.e., purchasers' prices, net realized prices, unit values, etc.) can help keep track of the direction and magnitude of the bias involved.

6. The current use of specification pricing and the manner in which new products are brought into the wholesale price index result in measures that deal inadequately with quality change taking place in various commodities. Hedonic price measurements and the use of functional specifications may in certain cases be helpful, but as in the case of transaction price indexes, what is required is the exploration of a number of different methods for developing adjustment

Time Lag between Orders and Shipments	Number of Series			
	Order Prices	Shipment Prices	Unknown	Total
Spot or shelf	16	7	8	31
One week to one month	51	86	7	144
One month to three months	113	103	33	249
Three months to six months	42	4	11	57
Six months to one year	34	0	0	34
One year or more	12	0	0	12
Unknown	17	51	34	102
Total	285	251	93	629

factors. In view of the growing use of price indexes for escalation of contracts and wages, an understatement of quality change and the consequent overstatement of price change may have serious effects on the behavior of the economic system.

7. The BLS system of weighting wholesale price data results in general price indexes that are misleading. The use of value-of-shipment weights to combine commodity price data into aggregate price indexes results in overweighting of raw materials input and intermediate outputs. As a consequence, the behavior of the general wholesale price index unduly reflects the behavior of these commodities. In order to develop appropriate price indexes for different levels of aggregation, e.g., seven-digit product, five-digit product class, four-digit industry, and two-digit industry, a system of net output weights should be used that would weight the commodity price data by the amount of the commodity sold outside of the grouping for which the price index is being compiled. In addition to indexes based on net output weighting it would also be useful to compile value-added price indexes from input prices and output prices at a fairly detailed industry level.

8. The use by the Bureau of Labor Statistics of judgmental data collection rather than probability sampling prevents statistical estimation of sampling errors and reduces the efficiency of the collection effort. A sampling frame is needed as a basis for developing a probability sample; this already exists in other statistical agencies of the federal government and it should be obtained through cooperation with them.

Richard Ruggles

The Measurement of Business Inventories

The study of the measurement of business inventories that the National Bureau has undertaken for the Census Bureau is now in the drafting stage and was scheduled to be submitted to the sponsor this summer.

Some of the recommendations that will appear in our report have already been adopted by the Census Bureau. For example, all known LIFO firms are now being asked for the first time to report LIFO and non-LIFO inventories separately on the monthly reporting form and to report their LIFO reserves. Firms that make bona fide LIFO calculations through the year when prices are rising should show variations in their LIFO reserves, but this is not always the case. The month-by-month reporting of an unchanging LIFO reserve is symptomatic of improper interim LIFO reporting and will require that such firms be treated by the Census Bureau as FIFO respondents. Also, companies that value their inventories on a standard cost basis are requested to report inventories on a comparable valuation basis for adjacent months when a change in the cost standard occurs. Previously, changes in inventories that reflected changed cost standards went undetected.

A major recommendation of our report will call for dual reporting requirements based on the size of the reporting unit. Small firms, representing mainly single-plant companies, will report as in the past. Large multidivisional firms will be asked to report total domestic inventories with divisional breakdowns each month. Year-end figures of such firms, with special information pertaining to the year-end closing, will constitute the annual benchmark for this group. In the past, plant totals provided through the Annual Survey of Manufactures constituted the benchmark even though inventory valuation methods at the plant and divisional levels were sometimes quite different. The Census Bureau has already embodied this recommendation in their latest budget request. It is of interest that our recommendations regarding divisional reporting units coincide with the announcement of new standards by the Financial Accounting Standards Board for financial reporting by diversified companies. The new standards pertaining to "segments" of a business enterprise, or what could be called rules for disaggregation, should not only make corporation financial reports more meaningful to investors and the general public but should also

be of assistance in the Census Bureau's statistical programs.

Other aspects of our study have been mentioned at earlier dates. Since the last progress report to NBER we agreed to examine the Census Bureau's statistics on unfilled orders in order to improve current benchmarking procedures.

Murray Foss
Gary Fromm
Irving Rottenberg

3. BUSINESS CYCLE RESEARCH

Introduction

Business cycle developments received much public attention during 1976, and the work of the National Bureau in this field, past and present, seemed particularly germane. The so-called pause in the recovery during the late summer and early autumn was one of the big events of the season, both during and after the political campaign. To some it recalled the pauses in earlier recoveries, during the 1950s and 1960s as well as before World War II. Indeed, to a few, among them Arthur Burns, it recalled Wesley Mitchell's observation that a pause in mid-expansion was a common characteristic of the business cycles that he had devoted a lifetime of study to. To most it was a brand-new experience, a demonstration of the weakness and fragile nature of the expansion itself, a problem that required special attention and an extra dose of government stimulation.

The index of leading indicators, published currently by the Department of Commerce but a product of earlier NBER research on the factors that generate business cycles, was partly responsible for the election-year excitement about the pause. The declines in the preliminary figures for this index in August and September, and its sluggishness in October, made front-page news. Unfortunately, virtually no attention was paid to the fact that preliminary figures are subject to revision. Even less excusable was disregard of previous experience that a small decline or a leveling off in this index after about a year of recovery is par for the course. It has been connected, in the past, with the unsustainable upsurge in inventory investment that usually occurs early in a recovery. It was so connected in this instance, since final sales (that is, GNP excluding the change in inventories) showed no pause in its rate of expansion.

The subsequent revisions in the leading index almost erased the decline, leaving only a small dip (less than one-half of 1 percent from July to September), with new highs being reached in October, November, and December (see Chart 3.1). The experience underlines the need for better and more promptly reported data (requiring less extensive revision) and for closer attention to historical studies of the kind the National Bureau has specialized in.

This experience and others like it make one think it might be desirable to establish a continuing system for monitoring the statistical quality of the more important economic indicators issued by the federal government. A small research staff, knowledgeable in the history, behavior, and methodology underlying these figures, could explore problems they find or that are brought to their attention, consider and propose solutions, and prepare reports on their findings. Some of these reports might be technical, others for wide circulation. To ensure objectivity and appropriate attention to priorities an advisory committee of data users from business, labor, government, and universities could be set up to guide the work and review the results. We are considering plans for an enterprise of that sort.

Some problems of the kind that might be attacked in such a project were brought to light during the year. It was found, for example, that the widely used monthly

CHART 3.1

RECOVERY PATTERN: INDEX OF TWELVE LEADING INDICATORS
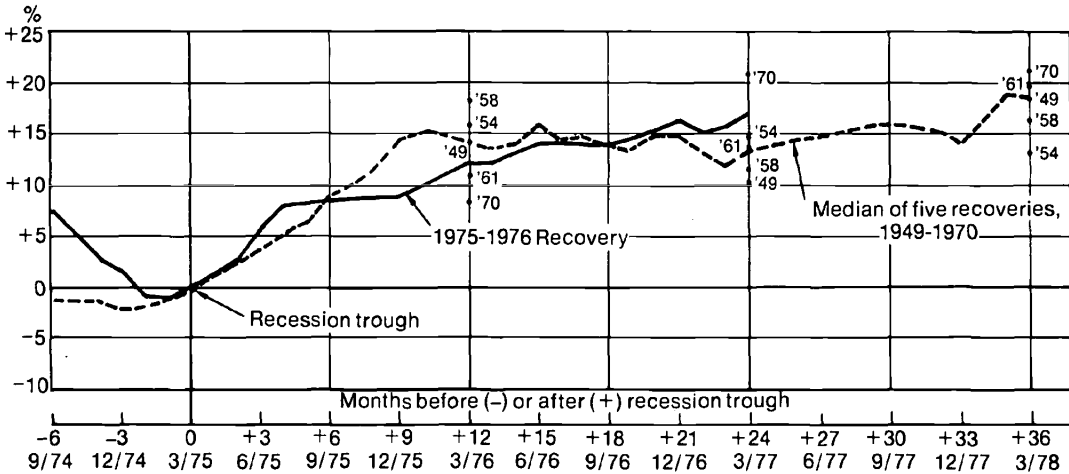
Explanation of Chart: Changes in the index from the business cycle trough to the current month are expressed as percents of the preceding business cycle peak. The peak and trough levels are centered three-month averages. For the current recovery, the preceding business cycle peak level, November 1973, is 130.1, and the trough, March 1975, is 107.6 (1967 = 100). The five earlier recoveries are identified by the year in which the trough month occurred: October 1949, May 1954, February 1961, and November 1970.

series on real spendable earnings of a worker with three dependents understates the average level of that worker's earnings, as reported in other government data, by about 35 to 40 percent, and also fails to reflect the rising trend in his real earnings over the past ten years (see my article in the *Morgan Guaranty Survey,* October 1976). A quite different problem besets the ratio of prices to unit labor cost in manufacturing, one of the leading indicators published in *Business Conditions Digest.* This ratio suggests that prices rose about 25 percent faster than costs during the past ten years, but is contradicted by other government data that show prices rising at about the same pace as unit labor costs. The latter result is much more consistent than the former with the trend of corporate profit margins during the same period. These are but two of the many problems that could well receive more attention if a program for monitoring the quality of government economic statistics were organized.

The need for continuing studies of business cycle experience and the development of data for observing this experience currently and comparing it with the past also were demonstrated by our study of international economic indicators. A simple table was constructed, showing the number of countries (of the seven covered in our study so far) experiencing recession or recovery month by month during 1973–1976. The results are depicted in Chart 3.2. It shows how the worldwide recession of 1974–1975 could be observed to spread among those seven major industrial countries and that the process could be seen a few months earlier in the leading indicators than in the coincident ones. Similarly, the recovery spread gradually from country to country and could also be observed a few months earlier in the leading indexes.

Now the fact is that most of the indicators that are reported widely on an international scale are coincident ones (industrial production, shown separately in the chart, is among them). Leading indicators, like new orders received, construction work started, or the average workweek, are as a rule either not reported by international sources at all or are not seasonally adjusted or are not deflated for price changes or are not up to date. Furthermore, the problem of acquiring comparable monthly data historically, so

CHART 3.2

NUMBER OF COUNTRIES WITH RISING INDEXES OF ECONOMIC PERFORMANCE, 1973–1976
(includes seven countries: Canada, the United Kingdom, West Germany, France, Italy, Japan, and the United States)
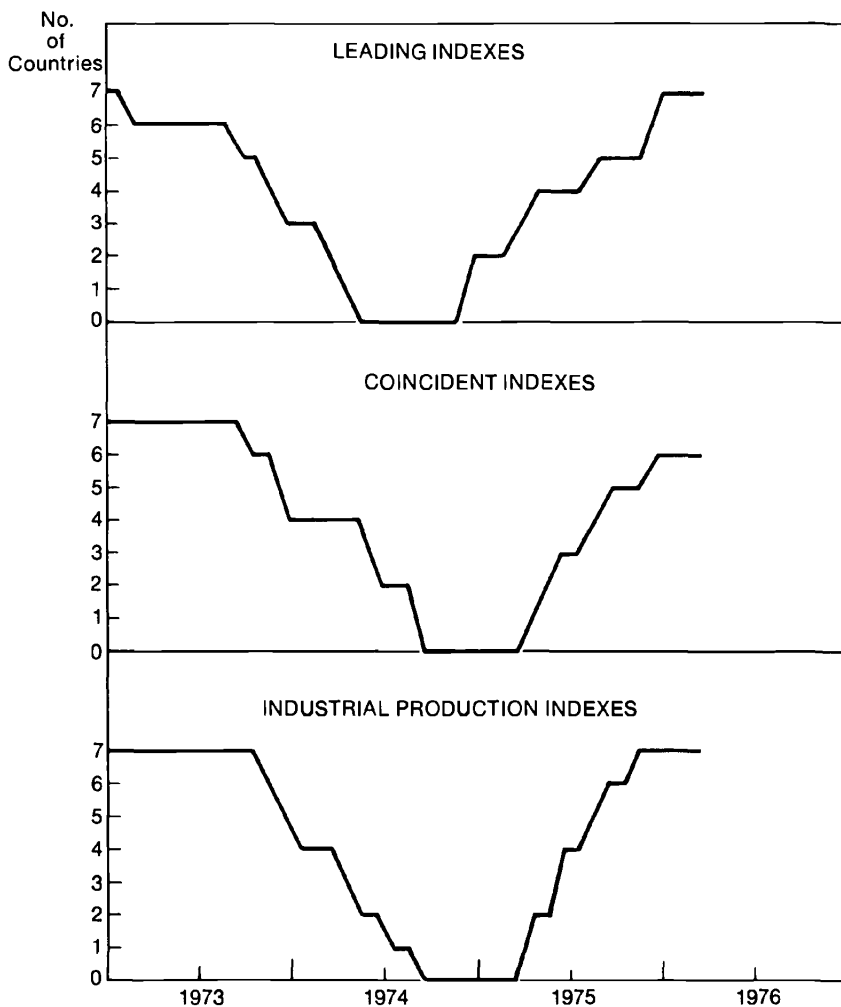
that the behavior of these indicators during previous business cycles can be analyzed and understood, is a time-consuming chore. With the limited resources we have managed to obtain, enough has been accomplished to demonstrate the practical value of the results (for further details see the report by Moore and Klein below). The Organization for Economic Cooperation and Development (OECD) has recently expressed interest in collecting the necessary data from member countries and exchanging them for the composite indexes and other measures we derive from them. We hope that this year will see the beginning of a current NBER international indicators data bank that will make these products widely accessible.

The questions to which business cycle studies are addressed are of a continuing nature, requiring continuing investigation. Business publications and governmental reports make wide use of such results of business cycle research as the NBER chronology of peaks and troughs, comparative patterns of current and previous recoveries or recessions, lists of leading and lagging indicators and corresponding records of performance, and the like. During the past year, for example, the device of comparing the current recovery with previous recoveries, which was developed in National Bureau studies years ago, was used in virtually every business and government publication dealing with the business outlook. The comparisons pertained to production, prices, income, consumer spending, housing starts, capital investment, bank loans, interest rates, employment, unemployment, and profits.[1] This sug-

gests not only that the results of business cycle research are of practical value over long periods of time, but also that it is essential to re-examine previous findings from time to time in the light of a changing economic environment.

Without this continuous re-examination a general deterioration of the scientific quality of the inferences drawn from earlier work is likely to occur. How many, for example, are aware that the common view that the 1974–1975 recession was the most serious in the United States since the 1930s is subject to an important qualification, namely, that it is not true of employment? Measured by the decline in employment, the 1974–1975 recession was one of the shortest and mildest of the seven recessions since the 1930s. How many know why this is so, why it is true of employment but not of unemployment, and what it probably implies as to the nature of future recessions? Business cycle research is designed to uncover such questions and track down the answers (see the forthcoming NBER report, "The Recession and Recovery of 1973–76," by Victor Zarnowitz and me).

To take another example, it seems to me that the development and use of a chronology of the rate of inflation, analogous to what has been done with the business cycle chronology, is a timely subject for research. It has been documented in some initial studies that the rate of inflation as measured by the consumer price index has typically begun to rise at about the time the business cycle reached its lowest ebb. At such times unemployment is still high and capacity utilization rates are still low, but neither the one nor the other has prevented

1. Among the publications using this method of analyzing the current recovery that have come to my attention are the following: *Business Conditions Digest*, Appendix G, monthly; *The Conference Board Statistical Bulletin*, monthly; *The Current Business Picture*, Bankers Trust Company, Fall 1975; *Economic Report of the President*, January 1977; *Business Week*, McGraw-Hill Company, April 19, 1976; *Business Conditions, U.S.A.*, Irving Trust Company, Spring 1976, Spring 1977; *Quarterly Business Conditions Analysis*, Manufacturers Hanover Trust Company, June 1976; *The 1976*

Midyear Review of the Economy, Report of the Joint Economic Committee of the Congress of the United States, 94th Cong., 2d sess., September 29, 1976; *Business in Brief*, Chase Manhattan Bank, October 1976; *Economic Forecast*, Prudential Insurance Company, November 26, 1976; *Business and Money Review and Outlook, 1977*, Harris Trust and Savings Bank, November 29, 1976; *The Pocket Chartroom*, Goldman, Sachs & Company, December 1976–January 1977; *Annual Report*, Federal Reserve Bank of New York, 1976; *Wall Street Journal*, March 14, 1977.

the rise in demand from spreading to more and more prices and raising the rate of inflation in the process. As Arthur Burns wrote in 1951, viewing the records compiled at the National Bureau before World War II, "Inflation does not wait for full employment."[2] How many, besides Burns, have become aware that every cyclical recovery since World War II has supported this statement? How many were surprised, during the current recovery, when the inflation rate climbed from its low point in the spring of 1976 to an uncomfortably high level a year later, despite unemployment rates that had risen to about 7 to 8 percent and capacity utilization rates that were down to about 80 percent?

The lessons of experience in this regard are simply not well known. If they were, fewer would regard the unemployment rate as if it were a leading indicator of the inflation rate—i.e., that it must come down to a low level *before* the rate of inflation will rise. It is more nearly a coincident indicator, and not a very good one at that. With wider knowledge, through research, of what are the more reliable leading indicators of inflation—and what are not—perhaps those whose difficult task it is to judge what is going to happen to the general price level and what policies are best suited to deal with it might be able to do a better job.

All this leads me to note that the financial support that business cycle research has been getting from business, from government, and from foundations has not been keeping pace with the need for it. This might be understandable if it appeared that the business cycle itself, and the inflation that goes with it, had been conquered, that we knew all the answers and had the matter firmly in control. Obviously that is not the case. It would also be understandable if other approaches to the problems posed by business cycles had proved themselves superior in every respect and adequate to the task. I do not believe that is the case either.

The irony is that just when public interest in the subject has climbed to new heights, and public use of the findings that the National Bureau has contributed over the years is so widespread, we should experience more difficulty than ever before in obtaining the wherewithal to continue the work.

Geoffrey H. Moore

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

During the past year we revised Chapter 10 of our draft, dealing with money and interest rates, and completed Chapter 11, on long swings. The work that remains to be done is (1) a final revision of the existing draft, which numbers roughly seven hundred typed pages, (2) preparation of a final summary chapter and preface, (3) reworking of the many statistical tables to assure their consistency with our latest revised series, (4) the same reworking of our many charts, and (5) seeing the manuscript through the Bureau refereeing process (which we plan to begin in the next few months) and then through the press.

Partial support for the study for the year beginning April 1, 1977, has been provided by the Ford Foundation and the J. Howard Pew Freedom Trust.

Milton Friedman
Anna J. Schwartz

International Economic Indicators

An early objective of the International Economic Indicators (IEI) project was to apply well-tried NBER techniques to the dating of business cycles in a number of market-oriented economies. A further objective involved experimenting with the 1966 NBER list of leading, lagging, and roughly coincident indicators for the United States to see whether corresponding series would behave in the expected way in other countries. To accomplish these objectives, we have largely duplicated the twenty-six indicators for Canada, the United Kingdom, West Germany, France, Italy, and Japan, starting in the 1950s.

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2. Introduction to Wesley C. Mitchell's *What Happens During Business Cycles: A Progress Report* (New York: NBER, 1951), p. xxi.
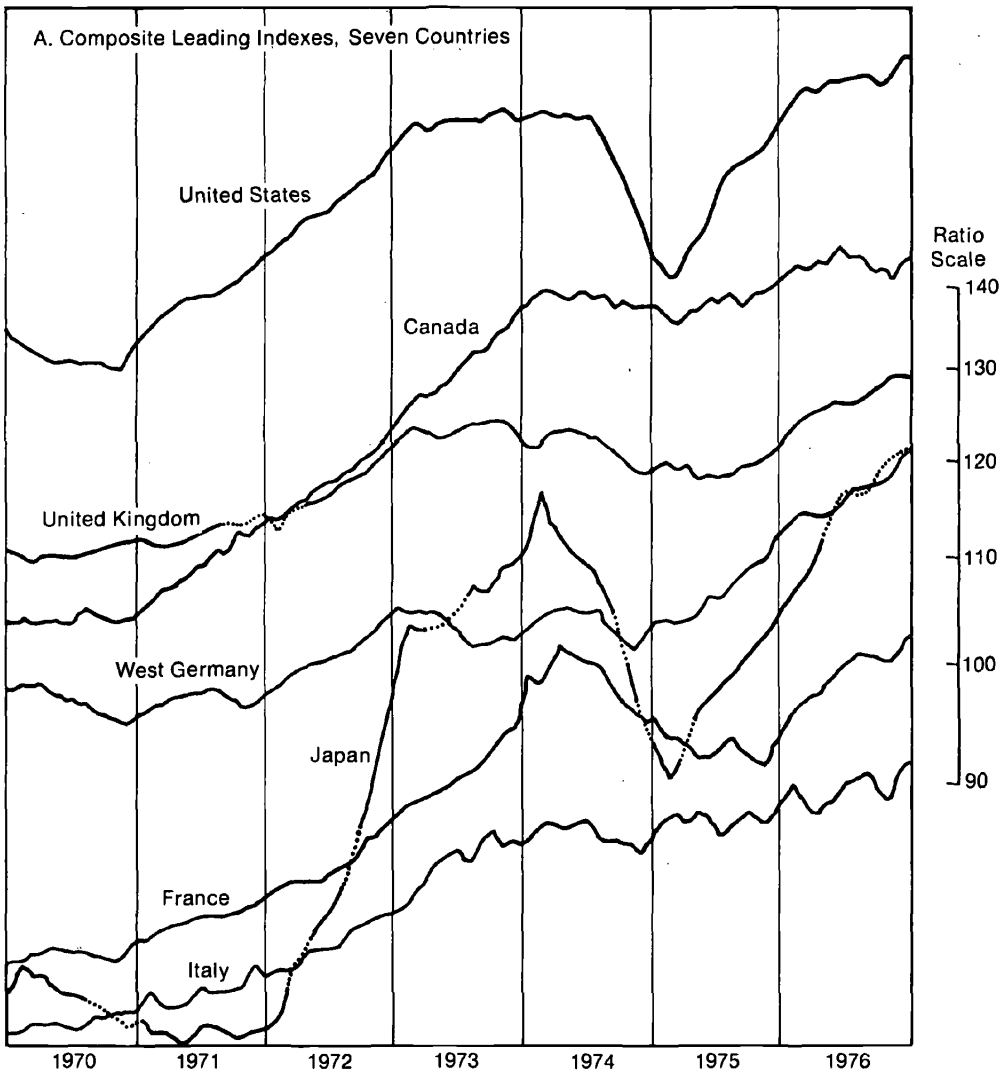
The results of this work have been sufficiently promising to induce the OECD and the national statistical offices of the countries listed above to agree to cooperate with the National Bureau on an experimental basis in setting up a current data bank for the indicator series and related measures. The plan includes the construction by NBER of composite leading, coincident, and lagging indexes and other summary measures useful in analysis of business cycle developments in each country. We hope that

the data bank can be in operation this year. The cooperating organizations, as well as other governmental and private users, will then have access to the current and historical data. It is our hope that it will greatly facilitate the accretion of knowledge on international instability and the manner of its transmission.

During 1976–1977 the IEI project made progress on several fronts. During the summer of 1976 and again in April 1977 the indicator data for the countries mentioned
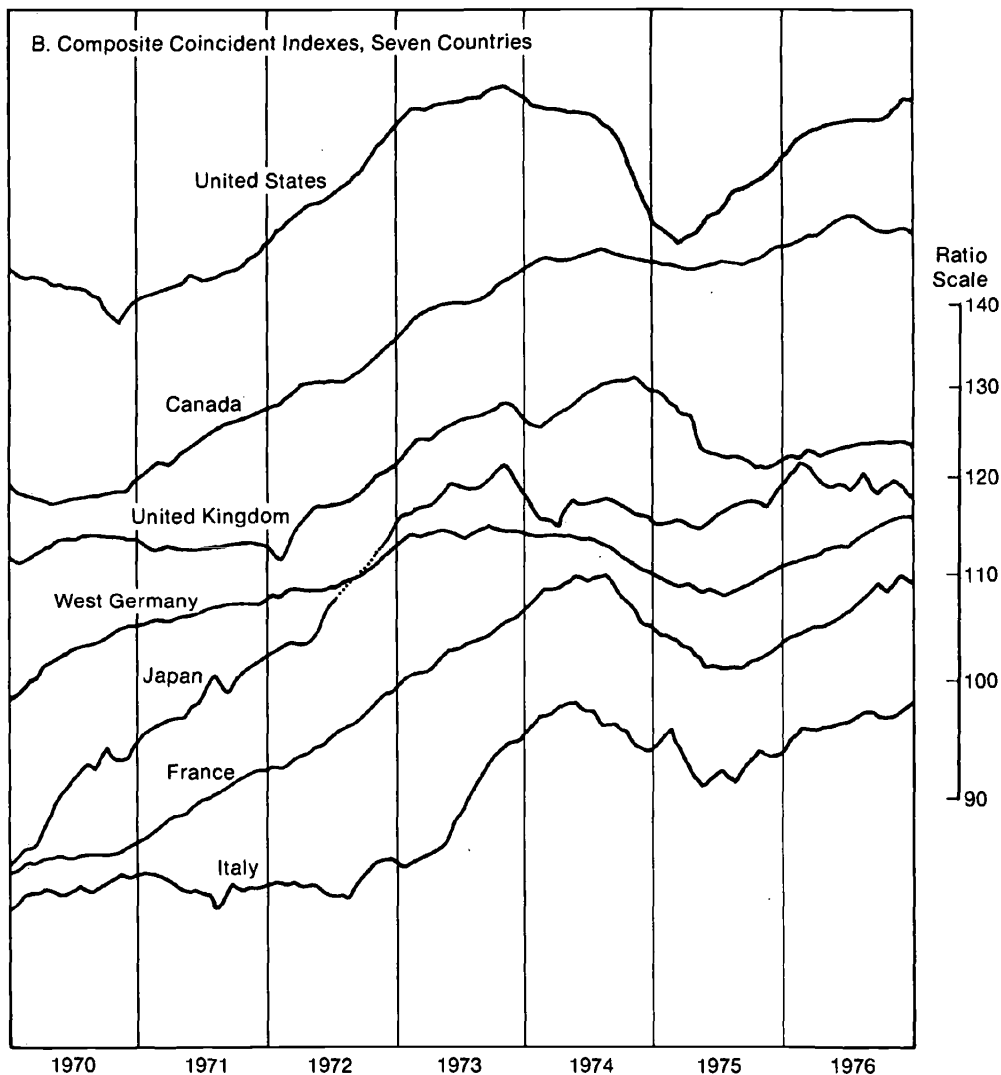
CHART 3.3

COMPOSITE LEADING AND COINCIDENT INDEXES, SEVEN COUNTRIES, 1970–1976

A. Composite Leading Indexes, Seven Countries

CHART 3.3 (*concluded*)

B. Composite Coincident Indexes, Seven Countries

United States
Canada
United Kingdom
West Germany
Japan
France
Italy

Ratio Scale
140
130
120
110
100
90

1970   1971   1972   1973   1974   1975   1976

above were brought up to date, i.e., beyond our original stopping point in 1973. We thought it was important to trace the indicator record through the recession suffered by all seven of the listed countries in 1973–1975 and to examine the extent of their recovery as well. At the same time we undertook to convert to a constant price basis all the indicators that are expressed in current prices. This change was introduced domestically as well by the Department of Commerce when the 1966 U.S. list of indicators was revised in May 1975.

We utilized the deflated series, along with updated versions of the other indicators, to construct composite indexes of the leading and coincident indicators for each of the seven countries and for all countries combined. During the relatively severe recession of 1973–1975 and the subsequent recovery the indicators generally behaved in a manner consistent with their earlier performance (Chart 3.3). We found the new measures were useful in showing the wide variation in rates of recovery experienced by these countries. We are persuaded anew of the importance of monitoring cyclical developments through a variety of economic time series rather than relying upon any single measure.

Another direction in which we have progressed recently has been in further experimenting with the use of leading indicators to forecast changes in U.S. trade flows. Because imports by market-oriented economies are closely associated with their domestic cycles, an exporting country can get a reasonably clear assessment of likely subsequent cyclical changes in its exports by examining the leading indicators of the country's trading partners. Chart 3.4 suggests the possibilities of this sort of approach. As a forecasting instrument we utilize the leading indexes for the United Kingdom, West Germany, France, and Italy, combining them by weighting each by the relative magnitude of the countries' GNP in 1970. The percent changes in this combined "Western Europe" leading index through December preceding the year to be forecast are then correlated with the subsequent year-to-year percent changes in U.S. exports to this region. This assumes implicitly that the leading index is a sensitive, early-warning measure of the demand for imports, and is reflected in actual imports six months hence. The chart shows both the forecast and actual changes in the physical volume of U.S. manufactured goods exports to Western Europe, 1964–1976. It is clear that the export volume as predicted by the four-country leading index conforms quite well to what the subsequent fluctuation in export volume proved to be. The correlation coefficient (R^2), reflecting the association between actual and forecast changes is

CHART 3.4

FORECAST AND ACTUAL PERCENT CHANGES IN U.S. EXPORTS OF MANUFACTURED GOODS TO WESTERN EUROPE, QUANTITY, 1964–1976, USING LEADING INDEX FOR FOUR COUNTRIES[a]
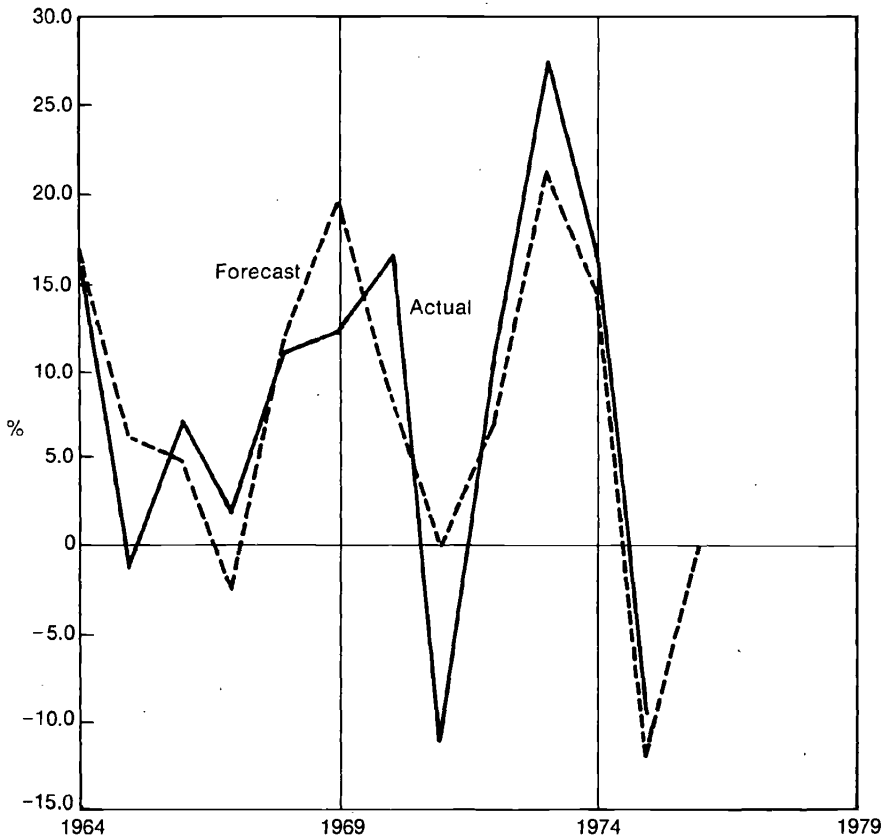
[a]United Kingdom, West Germany, France, and Italy, weighted by their GNP in 1970. $R^2 = 0.73$.

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0.73, i.e., about three-fourths of the fluctuation in the year-to-year change is accounted for. Some preliminary attempts to use this approach with quarterly rather than annual data have shown promising results.

Plans for an extension of the IEI research and development program have been drawn up. They include:

1. Organizing and maintaining a computer data bank for current leading and other indicators for a number of industrial, market-oriented countries;
2. Investigating new indicators and improving the quality of the international indicator system;
3. Investigating the synchronization of cyclical movements in different countries and the related tendency for the economy of the industrial world to experience waves of rapid growth and inflation alternating with slow growth or recession;
4. Testing and improving the trade forecasting method developed in our initial studies in terms of its application to monthly or quarterly data on imports, exports, and the trade balance;
5. Making comparative international studies of the cyclical behavior of closely related types of indicators, such as those pertaining · to investment, to financial markets, to labor markets, and to commodity prices. .

An ambitious program of this kind cannot, however, be undertaken unless the research funds available to the IEI project are substantially increased. During the past year the work has been supported by the departments of State, Treasury, Commerce, Labor, and Agriculture, the Federal Reserve System, and a number of American corporations. Reports published and in preparation are as follows:

Published

Moore. "The State of the International Business Cycle." Business Economics, vol. 9, no. 4, September 1974.
____. "Economic Indicators and Econometric Models." Business Economics, vol. 10, no. 4, September 1975.

U.S. Department of Commerce, Office of Competitive Assessment. "New International Business Cycle Indicators System: Applying the NBER Indicator Approach to International Growth Cycles." September 1975.
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Klein. "Postwar Growth Cycles in the United Kingdom: An Interim Report." Explorations in Economic Research, NBER, vol. 3, no. 1, Winter 1976.
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____. Business Cycles in the Postwar World: Some Reflections on Recent Research. Domestic Affairs Study 42. Washington, D.C.: American Enterprise Institute, 1976.

Moore. "Forecasting Foreign Trade Flows with Leading Indicators." The Business Economist, Society of Business Economists (Watford, Herts, England), vol. 8, no. 1, Summer 1976.

Moore and Klein. "Recovery—and Then?" Across the Board. The Conference Board, October 1976.

Moore. "Economic Indicators Needed Overseas." New York Times, January 16, 1977.
____. "Leading Indicators: A New Tool for Forecasting World Trade." Institutional Investor (International Edition), Institutional Investors Systems, Inc., March 1977.

Klein and Moore. "A New Index for the Economic Summit." New York Times, May 1, 1977.

Moore and Klein. "Summit Nations' Eco-

nomic Strength Building." Los Angeles *Times,* May 8, 1977.

In Preparation

Moore and Klein. "Monitoring Business Cycles at Home and Abroad." Draft, 242 pages.

‾‾‾‾‾. "The Development and Use of International Economic Indicators." Draft, 97 pages.

‾‾‾‾‾. "Forecasting Foreign Trade Flows with Leading Indicators." Invited paper for thirteenth CIRET (Centre for International Research on Economic Tendency Surveys) conference, Munich, September 1977.

Geoffrey H. Moore
Philip A. Klein

Cyclical Indicators

Further progress has been made in the analysis of U.S. growth cycles, that is, movements in aggregate economic activity defined by the consensus of fluctuations in comprehensive indicators adjusted for their long-term trends. The reference chronology of growth cycles has been established by a close examination of time series representing national output, employment and unemployment, income, sales, and industrial production. The series were obtained by dividing the successive observations for each indicator by the corresponding trend values, the trend having been estimated in such a way as to cut through, and contain no significant elements of, the short-term cyclical movements in the series.[1]

Chart 3.5 shows a monthly composite index, 1948–1976, constructed from eleven indicators expressed in the form of such deviations from trend. All components are series in constant dollars or physical units

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1. Specific turning points in the ratios of monthly (quarterly) data to centered 75-month (25-quarter) moving averages are used to break up the original series into segments, and the trend is then interpolated between the centered values of the averages of the data within these segments. Percentage deviations of the data from this trend form the final trend-adjusted series.

CHART 3.5

COMPOSITE INDEX OF DEVIATIONS FROM TREND, ELEVEN INDICATORS IN PHYSICAL UNITS OR CONSTANT DOLLARS, 1947–1976
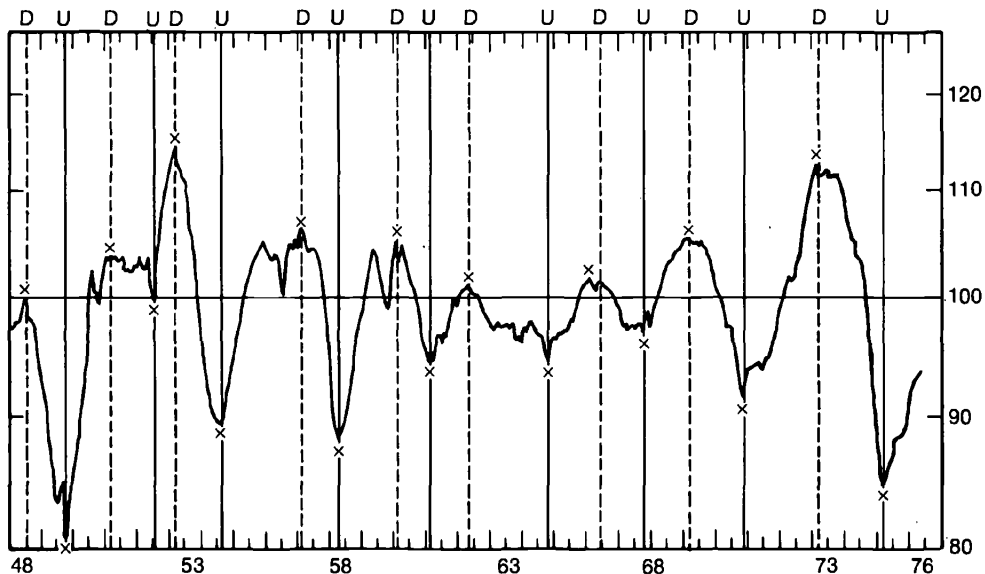
Note: U and D are growth cycle upturns and downturns, respectively. Crosses (x) denote upturns and downturns of the composite index.

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TABLE 3.1

BUSINESS CYCLE EXPANSIONS AND CONTRACTIONS AND HIGH- AND LOW-GROWTH PHASES IN THE UNITED STATES, 1948–1975

Business Cycle Reference Dates		Duration in Months		Growth Cycle Reference Dates		Duration in Months	
Trough (T) (1)	Peak (P) (2)	Contraction (P to T) (3)	Expansion (T to P) (4)	Upturn (U) (5)	Downturn (D) (6)	Low-Growth Phase (D to U) (7)	High-Growth Phase (U to D) (8)
	Nov. 1948				July 1948		
Oct. 1949		11		Oct. 1949	March 1951	15	17
	July 1953		45	July 1952	March 1953	16	8
May 1954	Aug. 1957	10	39	Aug. 1954	Feb. 1957	17	30
April 1958	April 1960	8	24	April 1958	Feb. 1960	14	22
Feb. 1961		10		Feb. 1961	May 1962	12	15
				Oct. 1964	June 1966	29	20
	Dec. 1969		106	Oct. 1967	March 1969	16	17
Nov. 1970	Nov. 1973	11	36	Nov. 1970	March 1973	20	28
March 1975		16		March 1975		24	
Average		11	50	Average		18	20

Source: National Bureau of Economic Research, Inc.

or quantity index numbers.[2] The solid vertical lines denote upturns (U), the broken vertical lines downturns (D), of U.S. growth cycles. It is apparent that these phases are on the average of similar length, unlike business cycles where expansions tend to be much longer than contractions because the rising trend of activity prolongs expansions and shortens contractions.

Table 3.1 compares business cycles and growth cycles in terms of their timing and duration. Since 1948, five complete business cycle expansions and six contractions are identified, with average durations of 50 and 11 months, respectively; also, eight complete high-growth and nine low-growth phases, with average durations of 20 and 18 months. A growth cycle downturn (D) preceded each of the six business cycle peaks (P) of the 1948–1973 period by intervals ranging from 2 to 9 months, and averaging 5.5 months. Clearly, each recession followed the onset of a low-growth phase. On the other hand, all but one of the six business cycle troughs (T) coincided with growth cycle upturns (U). (In 1954, U lagged behind T by 3 months.) Thus, recovery was approximately synchronous with the onset of a high-growth phase. On three occasions since 1948—in 1951–1952, 1962–1964, and 1966–1967—low-growth phases interrupted business expansions but did not degenerate into business contractions.

. Ten out of 15 dates in the NBER growth cycle chronology for 1948–1969 are identical with those derived earlier by Ilse Mintz,[3] and all but one of the others are close, the exception being the 1964 upturn. This similarity of results obtained independently in studies using somewhat different data and techniques is reassuring. In another test of the robustness of the present approach the method of trend adjustment outlined above was applied directly to the composite indexes of leading, roughly coincident, and lagging indicators currently published in Business Conditions Digest (BCD) of the Bureau of Economic Analysis. It should be noted that the NBER reference cycle dating is based on an examination of

2. Other composite and diffusion indexes were used as well, including some with seven additional series in current dollars. The results generally resemble each other closely.

3. "Dating United States Growth Cycles," Explorations in Economic Research (Summer 1974). The comparison refers to the dates based on the set of indicators in real terms used in Mintz's study.

CHART 3.6

TREND-ADJUSTED COMPOSITE INDEXES OF U.S. LEADING, ROUGHLY COINCIDENT, AND
LAGGING INDICATORS, 1948–1976
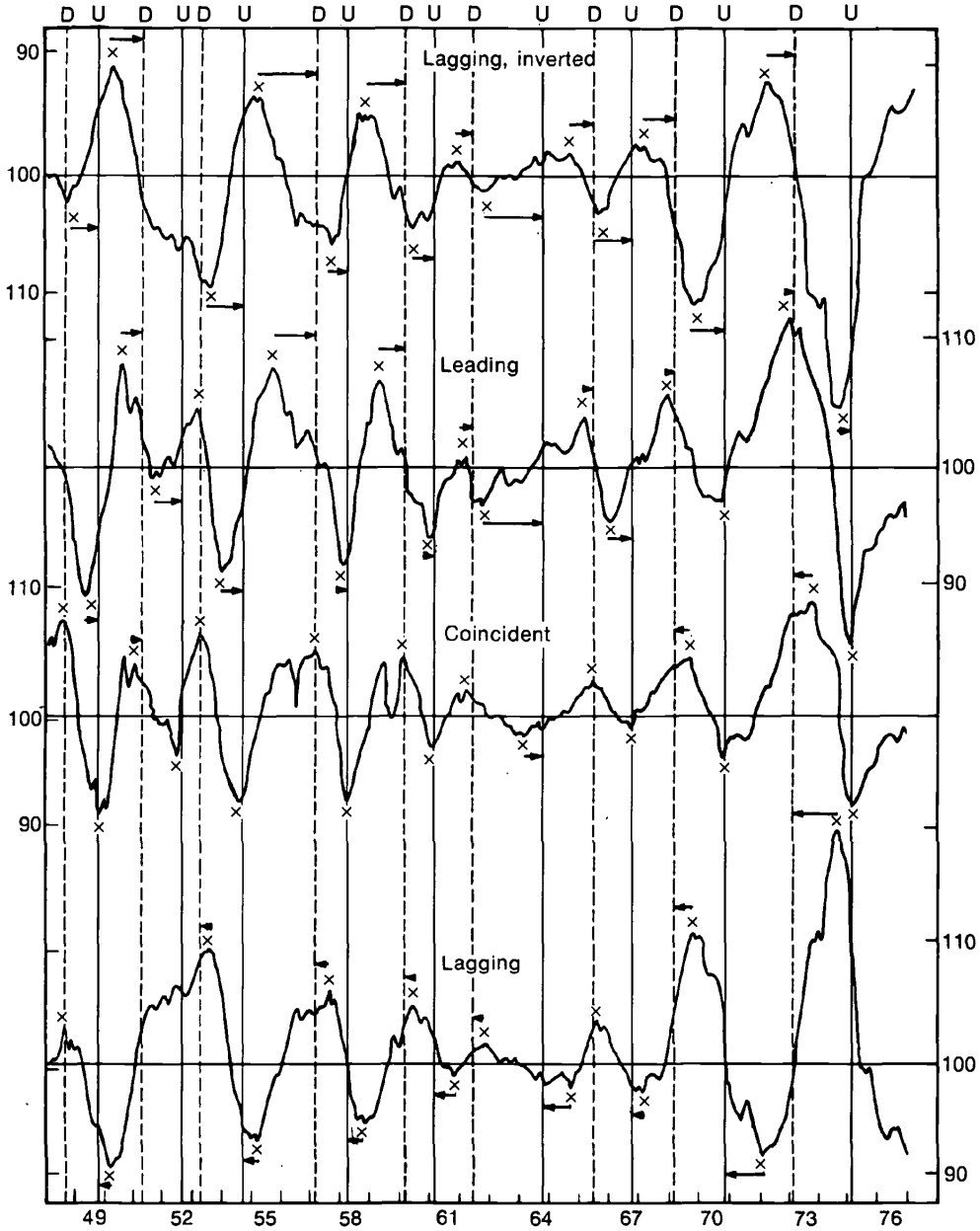
Note: U and D are growth cycle upturns and downturns, respectively. Arrows denote leads and lags. Crosses denote upturns and downturns of the composite indexes.

many more series than the four that comprise the new revised index of roughly coincident indicators; also, that we are using the trend-adjusted indexes, not indexes computed from trend-adjusted component series. Because of these and other differences in the composition and construction of the indexes used, there was nothing in our procedure that would necessarily assure the transformed *BCD* indexes of a

good record of conformity and timing in the growth cycle context. As shown in Chart 3.6 and Table 3.2, however, the record is reasonably good. The leading index shows 16 leads and 2 coincidences at the 18 turns covered; the coincident index, 12 coincidences, 4 leads and 2 lags; and the lagging index, 15 lags. The timing averages are all in the proper ranges. Evidently the series that tend to lead at business cycle peaks and troughs also tend to lead at growth cycle downturns and upturns, and analogously for the roughly coincident and lagging indicators. The timing measures listed show considerable dispersion but this is also true of the timing of the original indexes at business cycle turns. The main problems are with the weakest growth cycles whose dating has been difficult: the lagging index does not conform well to the 1951–1952 low-growth phase and the leading index has an especially early upturn in the 1962–1964 phase.

In accordance with what would be expected from the trend elimination, there are no marked asymmetries between the leads and lags at growth cycle upturns and downturns (unlike in the business cycles of the same period, where long leads are observed mainly at peaks and long lags mainly at troughs). Because of the similar duration of high-growth and low-growth phases, one of the desirable characteristics of lagging indicators—their lead relative to

TABLE 3.2

TIMING OF TREND-ADJUSTED COMPOSITE INDEXES AT GROWTH CYCLE TURNING POINTS, 1948–1975

Growth Cycle Reference Dates		Composite Indexes of Trend-adjusted Indicators; Leads (−) or Lags (+) in Months							
		Leading		Roughly Coincident		Lagging		Inverted Lagging	
Upturn (U)	Downturn (D)	U	D	U	D	U	D	U	D
	July 1948		−6[a]		0		+1		
Oct. 1949		−4		0		+5		−14	
	March 1951		−7		−2		b		−12
July 1952		−11		0		b		b	
	March 1953		0		0		+4		b
Aug. 1954		−7		0		+8		−13	
	Feb. 1957		−17		0		+7		−22
April 1958		−3		0		+7		−7	
	Feb. 1960		−10		−1		+4		−15
Feb. 1961		−2		0		+9		−8	
	May 1962		−3		−1		+6		−6
Oct. 1964		−24		−7		+11		−23	
	June 1966		−3		0		+2		−9
Oct. 1967		−9		0		+5		−14	
	March 1969		−2		+7		+7		−12
Nov. 1970		0		0		+16		−13	
	March 1973		−1		+8		+18		−12
March 1975		−1		0		c		−6	
Median		−4	−3	0	−1	+8	+5	−13	−12
Mean		−6.8	−5.4	−0.8	+1.2	+8.7	+6.1	−12.2	−12.6
Standard deviation		7.4	5.4	2.3	3.6	3.9	5.3	5.4	5.0

[a] Measured from the highest value for the available data which begin in January 1948.
[b] No specific cycle (no turns corresponding to the indicated reference dates can be clearly identified).
[c] Not identified.

the opposite turn of the leaders—is much more consistent for the trend-adjusted indexes than for the original ones. As can be seen by comparing the first two columns of Table 3.2 with the last two, the turns of the trend-adjusted laggers lead the opposite turns in the trend-adjusted leaders at all turns except the 1964 upturn, where the leaders lead by 24 months and the inverted laggers by 23. The mean leads of the inverted lagging index are 6 months at peaks and 6.4 months at troughs of the leading index, and the corresponding standard deviations are 4.1 and 2.9 months.

A new revised edition of *BCD* was introduced in November 1976 as a result of a comprehensive study of business cycle indicators conducted by the Bureau of Economic Analysis in collaboration with the research staff of the National Bureau. *A Handbook of Cyclical Indicators* will be published shortly as a supplement to *BCD*.

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Victor Zarnowitz
Charlotte Boschan

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Regularity of Growth Cycles

While at the Bureau as a research fellow under the program supported by the Sloan Foundation, I have been extending my earlier work (*Economic Inquiry,* September 1975) on what Irving Fisher called the Monte Carlo cycle in business activity. In my earlier work the expansions and contractions implied by the standard NBER chronology were examined for evidence of nonrandomness, with negative results. I have extended this to the newer Mintz growth cycle chronology, again with negative results. However, these negative results are not very conclusive, given the present short duration (only since World War II) of the growth cycle chronology. Geoffrey Moore has called to my attention the longer trend-removed series on aggregate activity of Frickey, Ayres, Persons-Barrons, and the American Telephone and Telegraph Company. In the near future, I plan to investigate the regularity of the expansion and contraction durations implied by these series.

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J. Huston McCulloch

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The Recession and Recovery of 1973–1976

This study has two major objectives: (1) to review the evidence concerning the factors involved and the timing of the 1973–1976 sequence of slowdown, recession, and recovery; and (2) to measure the severity of the recession and the vigor of the recovery in comparison with earlier cyclical contractions and expansions. During the past year we completed a report and circulated it for review by the staff and others. A revised version will soon be submitted to the Board of Directors.

The expansion that began near the close of 1970 moved in the spring of 1973 into a low-growth phase during which some sectors of the economy declined or weakened while others continued to enjoy strong demand and in some cases encountered shortages of the required materials. The balance tipped toward a decline in aggregate output in the last quarter of 1973.

Both the decline in output and the rise in unemployment were considerably larger in the 1973–1975 recession than in any of the five earlier recessions of the period since World War II, but the reduction in total employment was relatively mild. The sharp increase in the rate of inflation during the first half of 1974 had no precedent in earlier U.S. business contractions. The peculiarities of this episode derive in the first place from the impact of the unexpected acceleration of the general price rise and shortages of materials; later on, from continuing fears of a recurrence of such phenomena and the consequent caution in private and public decision making. Consumer outlays on housing, automobiles, and other durable goods, expressed in constant prices, declined substantially after the first quarter of 1973, but business investment in structures rose, albeit slowly, for another two quarters, and investment in equipment rose for another year. Output of nondurable consumer goods did not turn down decisively before the fall of 1974, and the volume of services purchased by consumers did not decline at all during the

recession. It is not easy to explain crosscurrents or lags of this type and size, either in theoretical or statistical terms. Some of the data inspire skepticism, and there may be large systematic errors because of the extraordinary rise in prices and the difficulties of measurement, especially of inventories, that this occasioned. The problem is made evident by the large revisions of the data that have been and are still being made.

Restrictive actions on the supply side, which tend to produce rising prices along with falling output, played a prominent role in 1973–1974, probably more so than in most business cycles of the past. However, weaknesses on the demand side, which contribute to output reductions but may counteract price rises, developed early in housing and later became more and more apparent generally. This resulted in sharp inventory movements of a familiar cyclical type, which marked the rapid transition of the economy from the severe downswing of the fall and winter of 1974–1975 to the initially vigorous upswing beginning in spring 1975.

The recovery during 1975–1976 was on the whole moderate—closely resembling the average performance of total output and employment during previous recoveries. It was accompanied by a relatively weak revival of business capital formation and slow reduction of unemployment. At the same time, the declines in the rate of inflation and in interest rates, which are associated with each other as well as with the pace of the recovery, were unusually large by historical standards.

Victor Zarnowitz
Geoffrey H. Moore

Short-Term Economic Forecasting

About 160 individuals have participated at one time or another in the quarterly ASA/NBER Survey of the Economic Outlook, which was initiated late in 1968; 67 of these have been regular members in the sense that they submitted forecasts on at least twelve occasions (out of a total of twenty-nine surveys taken through 1975). Charlotte

Boschan and I are studying the distributions of these individual forecasts for real GNP, the implicit price deflator, industrial production, and the unemployment rate. Forecast errors are measured in their several dimensions by using alternative summary statistics and decomposition methods on predictions of both levels and relative changes. The factors to which the observed forecasting behavior and performance are being related include the characteristics of the jump-off and target periods, the span of forecast, and the methods reported by the forecasters. Error statistics are computed for forecasts of each individual covered and for selected subsets of the sample, cross-classified by variable, period, span, and principal method used. This will enable us to compare the individual with the corresponding group forecasts (means and medians) from the same surveys in an appropriately standardized form.

There is no presumption that individual participants are consistently as accurate as the average survey forecast; on the contrary, research so far indicates that averaging often helps to offset errors in component predictions. Our previous work has centered on the global results of the surveys, which have also attracted much attention of others, both at the National Bureau and elsewhere (V. and J. Su, Stephen McNees, Arthur Okun, Herman Stekler, *Economic Outlook USA,* and the *Conference Board Statistical Bulletin,* to mention some authors and sources). However, it is the individual forecasts that are the primary data and of major interest in their own right. We wish to find out which of them are relatively successful, when, and why.

For the period beginning in 1970, a record of forecasts based on econometric models has been assembled, including the Wharton, Bureau of Economic Analysis, Chase, and Data Resources, Inc., models. These forecasts combine the models with judgmental adjustments and (often several alternative) assumptions about exogenous factors. Forecasts of the MAPCAST group at the General Electric Company, which use individual econometric relationships in an

iterative process, are also available on tape. All forecasts in this set are generated quarterly for sequences of up to eight quarters ahead. They cover real and nominal GNP, seven major expenditure components of GNP, the implicit price deflator, and the unemployment rate. Although comprehensive and informative studies of the overall accuracy of these forecasts exist, much remains to be done to broaden and deepen the analysis of these and related materials both over time and cross sectionally. Forecasts differ by source, type, model, role of judgmental and other elements, timeliness, frequency, selection of exogenous variables, and complexity; the predicted variables, by economic significance and statistical properties; and the periods covered, by the nature of concurrent exogenous events and endogenous developments. These separate distinctions have been employed to formulate the kinds of comparisons to be made and questions to be asked.

The comparisons involve the individual and group forecasts from the ASA/NBER surveys; the forecasts with econometric models; predictions obtained with the aid of regressions of changes in real GNP and industrial production on lagged changes in the composite index of leading indicators; and extrapolative benchmark models of the general autoregressive–moving average variety. Many interesting questions need to be raised or reconsidered. Are some variables systematically more difficult to predict than others and, if so, what are their distinctive characteristics? Have some periods presented the forecasters generally with greater problems than others and, if so, why? Are there relationships between the types of forecasting errors (underestimation, overestimation, turning point errors) and the nature of the variables and periods involved? Stated more broadly, what if any are the time patterns of forecasts and their errors? How do forecasts vary between periods distinguished in terms of business cycle phases, degrees of inflation, and intensity of outside shocks? Are the reported forecasts consistent with the concepts or hypotheses of "rational expectations" and "efficient markets"—have they in effect utilized all predictive information from past data and models of economic theory? How do forecasts vary in these different respects, by type, variable, span, etc.?

Previous research provides some evidence on some of these questions, but a close analysis of multiperiod quarterly forecasts now available should be able to add much to our as yet very fragmentary knowledge of these matters. Even though the data are still limited to a rather short slice of history, they cover a variety of sources, methods, and experiences, and are in this sense quite rich. A grant from the Earhart Foundation is helping to support our studies of these data.

Victor Zarnowitz

4. FINANCIAL INSTITUTIONS AND INDUSTRIAL ORGANIZATIONS

Financial Institutions and Processes

Introduction

During the past year, National Bureau research on financial institutions and processes has continued to examine problems of inflation in the investment sphere and in financial markets and to study portfolio behavior as reflected in the actions of individuals and institutions.

As reported by Phillip Cagan and John Lintner, research on the impact of inflation on financial institutions and markets is in the process of publication. Included are studies on specific types of decisions and their overall impacts. Benjamin Friedman is constructing a model of the corporate bond market that combines equations based upon the actions of both the borrowers and the major purchasers of bonds.

Other research is concerned with the meaning for institutional and individual behavior of developments in portfolio theory

and knowledge. The work on capital adequacy draws both on modern concepts of portfolio risk and on detailed information about the way individual institutions have altered their distribution of assets and liabilities by major categories as the economy has moved through cycles of interest rates, prices, investment, and output. It is hoped that the results will enable those concerned with institutions to measure differences in risks associated with such portfolio decisions.

Other research is concerned with the theory, measurement, and analysis of individual portfolio actions in relation to market movements. The statement by Wilbur G. Lewellen furnishes more complete information on a variety of studies that have been or are about to be published.

Sherman J. Maisel

Regulations, Risks, and Capital Adequacy in Financial Institutions

Data show that over the past thirty years a dramatic shift has occurred in the composition of the assets and liabilities of banks. Both the percent of riskier, nonliquid assets and the ratio of purchased funds, particularly among large banks, have increased sharply. At the same time, the share of equity has fallen. There has been a general recognition that these changes have increased the risk of individual banks, but violent debates have taken place as to whether the added risk has caused a significant deterioration in the safety of individual banks and, if so, what to do about it.

Information from bank stock prices shows that the market has greatly increased its estimate of the risks involved in large banks. Whereas from 1945 through 1960, the beta, or relationship of changes in the price of bank stocks to the market average (Standard and Poors 500-Stock Index), was under 0.5, in recent years it has been well above 1.0.

We are attempting to model the balance sheets of different types of banks and other financial institutions to see how their net worth may be expected to respond to changes in macroeconomic variables. Such changes alter an institution's cash flow. They affect the returns to type of assets, the costs of liabilities, and the spread. Movements in the term structure of interest rates cause differing movements in the present value of future flows, depending upon the period in which they are expected. The NBER's *56th Annual Report* (September 1976) gives a more detailed explanation of the theory underlining this work.

We have specified a model of a wholesale bank to measure how its net worth changes as a result of such movements. We have estimated the equations with data from a single large bank. We have since expanded the specifications to banks in general and are in the process of estimating the model with micro data for a variety of bank types. We hope these models will show how specific differences in balance sheets relate directly to capital requirements.

We are examining in detail the types of changes that have occurred among different banks. We are estimating the impact of these changes on movements in bank returns as measured by both book and market values. We also are examining theory and practice concerning the costs of bank capital and their relationship to the form of insurance of deposits made available by the Federal Deposit Insurance Corporation and the Federal Savings and Loan Insurance Corporation.

We expect to have our results available by the end of fiscal 1978.

Sherman J. Maisel
David Lane
David H. Pyle
Barr Rosenberg
William F. Sharpe

The Effects of Inflation on Financial Institutions and Markets

Several reports which represent the final phase of this project are nearing completion. Three studies of the effects of inflation and interest rate expectations on invest-

ment decisions of financial institutions, scheduled for publication this year, are reported on below. A study of the effects of inflation on the various components of household saving, by Paul Wachtel, has been submitted to the Board of Directors. An overall review of recent research and experience of the effects of inflation on saving and investment by the different sectors of the economy and the consequences for financial markets has been prepared by Phillip Cagan and Robert Lipsey and will soon be ready for circulation.

This project has been supported by the American Council of Life Insurance.

Phillip Cagan

Investment Policies of Major Financial Institutions under Inflationary Conditions

Three of our studies have been revised in the light of staff and Board reviews and have been published or are in the process of publication in *Explorations in Economic Research*. These are "Income Participations on Mortgage Loans by Major Financial Institutions," by Piper, and "Interest Rate Expectations and Optimal Forward Commitments for Institutional Investors" by Lintner, both in volume 3, number 4, and "Warrants and Convertible Debt as Financing Vehicles in the Private Placement Markets" by Piper and Arnold, in volume 4, number 3. Our joint work on "Forward Commitment Decisions on Bonds and Mortgages by Life Insurance Companies" has been updated and revised preparatory to Board review.

The other paper described in previous reports, on testing the log-normality of securities returns over holding periods of different lengths, and developing the implications of log-normality of returns for portfolio selection and market equilibrium, will be submitted for publication shortly.

John Lintner
Thomas Piper
Peter Fortune

Modeling the Corporate Bond and Government Securities Markets

This project is proceeding along three principal avenues: First, I am continuing to refine the structural model of interest rate determination in the corporate bond market. One recent result in this regard indicates that the past histories of both bond and short yields, which may perhaps be interpreted as reflecting expectations of future yields, have a significant and sizable influence on borrowers' supply of and lenders' demand for bonds, and hence on the current bond yield as well. Another recent result, supported by several different elements of evidence, indicates that bond investors' portfolio behavior is characterized by risk aversion of such nature and degree as to render bonds and other assets highly imperfect substitutes for each other. One part of the evidence for this finding is that bond investors' portfolio responses to changes in the (uncertain) expected capital-gain-or-loss component of the holding period yield on bonds are significantly smaller than their responses to equivalent changes in the (certain in the absence of default risk) coupon component of the holding period yield. A second part of the evidence is that the respective yield variances on bonds and on competing assets significantly influence investors' portfolio allocations in much the way suggested by the capital-asset-pricing model.

Secondly, Vance Roley is constructing a structural model of interest rate determination in the U.S. government securities market, disaggregated by four maturity groups. Thus far the model is complete for securities of two to five years and five to ten years; these two submodels perform well empirically, providing further support for the use of structural models of interest rate determination. An especially interesting element of this model is an asymmetrical treatment of commercial banks' management of their securities portfolios according to which increases and decreases in the size of the portfolio have differential effects on the portfolio allocation.

Thirdly, David Jones and I are estimating the various "bridge" relationships which will facilitate putting the corporate bond market model into the MPS model as a replacement for the MPS term-structure equation. This work is about half completed.

Benjamin M. Friedman

Misintermediation and Business Fluctuations

Misintermediation is the mismatching of the maturity structures of an intermediary's assets and liabilities. In NBER Working Paper 160, I argue that misintermediation permits the intertemporal mismatching of consumption and production plans, resulting in business fluctuations. During my year as an NBER fellow I am, among other things, continuing research into empirical implications of this model in two directions.

One direction is to measure as precisely as possible unanticipated movements in interest rates associated with historical business fluctuations. I have reported elsewhere on modifications I made while at the Bureau to my program for spline curve fitting the term structure of interest rates. I have also developed a formula for a forward long-term bond yield, which can be calculated very easily from the current short-term interest rate and long-term bond yield. This formula has a precise relation to instantaneous forward rates as the long bond approaches a perpetuity. I have written a short paper on this forward bond yield for journal publication.

The second direction is to quantify historical misintermediation prior to actual business fluctuations. Thrift institutions should be particularly important, as they are based on long-term assets and virtually demand liabilities. A complication of my preliminary analysis of thrift institutions has been that the relevant liability maturity is not their contractual maturities, but rather the (unobservable) planned withdrawal dates. Inferences about these plans from subsequent behavior is clouded by real interest rate changes, by unanticipated inflation, and by generational turnover. I am still at the stage here of developing concepts.

J. Huston McCulloch

Individual Investor Portfolio Performance

A concern with possible institutional dominance of the market for equity securities has prompted a number of studies of the trading behavior and portfolio policies of those entities. Direct data on the cor-responding dimensions of individual investor activities, at the micro level, have not generally been available, however. Through the cooperation of a large national retail brokerage house, I have been able to compile such data for a large sample covering the period 1964 through 1976, and have supplemented it with questionnaire surveys of the sample group. The approach, scope of the data, and some of the early findings were outlined in previous reports and are summarized in papers published in the *Journal of Finance*, May 1974 and May 1975, and the *Financial Analysts Journal,* September–October 1976.

The past year has been spent in extending the analysis in those papers, which dealt primarily with the questionnaire responses, to the measurement of investment performance by the sample, to updating the data, and to investigating a range of ancillary behavioral issues. The results are contained in several additional papers either scheduled for 1977 publication or currently under review.

Of these, perhaps the major set of findings will be presented in two papers to be published in the *Journal of Business,* July 1977 and October 1977: "Patterns of Investment Strategy and Behavior Among Individual Investors" and "Realized Returns on Common Stock Investments: The Experience of Individual Investors." These deal with the linkages between attitudes, attributes, and behavior and with investment performance from 1964 through 1970, for which transactions data are presently available for the sample. Surprisingly favorable investment results emerge in the figures portrayed, suggesting some reasonable acumen in security selection on the part of the group. Other papers due to be published are "Stock Exchange Listings and Securities Returns," in the *Journal of Financial and Quantitative Analysis;* "Some Evidence on the Patterns and Causes of Mutual Fund Ownership," in the *Journal of Economics and Business,* and "An Empirical Analysis of Brokerage House Securities Recommendations," in the *Financial Analysts Journal.* All are offshoots of the

main study, and are made possible by the data base compiled for it. Several other manuscripts are in the working paper stage.

The coming year will be devoted to bringing the data base on securities prices and transactions up to date through December 1976, to executing a new questionnaire survey of the sample, and to examining alternative investment performance measures and perspectives. Moreover, work has begun on the possibility of developing a survey instrument that will yield an "investor sentiment index" comparable to the Survey Research Center's Consumer Sentiment Index, which might act as a leading indicator both of market trading volume and securities price movements. Exploratory efforts in this connection have been initiated with a sample to be provided by the cooperating brokerage house. Grants from it and from the Investment Company Institute are the major sources of project financial support.

Wilbur G. Lewellen

Industrial Organizations

Introduction

The Bureau's current studies in this area are focused on the process of innovation. One, reported on below by Michael Gort, deals with the way in which a product innovation is diffused throughout an industry. Another, described by Henry G. Grabowski and John M. Vernon, analyses the effects of regulation on the costs and rate of innovation in the drug industry. Also of interest to those concerned with the determinants of the rate of technical progress is M. Ishaq Nadiri's study, Research and Development and Firm Productivity, discussed in section 2, above.

The program of research on organization of markets, now almost completed, has dealt mainly with advertising as a form of information and as an influence on demand and market shares and with the more traditional industrial organization subjects of the effects of concentration and product diversification. Michael Gort reports on this set of studies below.

Aside from the recent and forthcoming papers listed in the reports in this section, another one on a related topic is John C. Hause's "The Measurement of Concentrated Industrial Structure and the Size Distribution of Firms," in *Annals of Economic and Social Measurement,* volume 6, number 1 (Winter 1977). The Bureau has also been developing some enterprise data sets that should be useful in future studies of industrial structure. These are reported on in section 1, above.

Robert E. Lipsey

Organization of Markets

This research program on the organization of markets was financed jointly by the Educational Foundation of the American Association of Advertising Agencies and the National Bureau of Economic Research. It is approaching completion with two studies published in *Explorations in Economic Research,* one by Henry Grabowski on interindustry effects of advertising on demand and the other by Rao Singamsetti and me on concentration and profit rates. Two additional studies have passed the staff review stage and are being revised for publication, one by Grabowski on the impact of advertising on market shares in five industries and the other by Phillip Nelson on advertising and information. A fifth study on trends, determinants, and consequences of product diversification (jointly with Grabowski and R. McGuckin) is being prepared for staff review.

A summary of the results of the five studies was prepared by Hedy D. Jellinek and has been published by the AAAA.

Michael Gort

Diffusion of Product Innovations

This study, financed by the National Science Foundation, is approaching completion. One paper, "Time Paths in the Diffusion of Product Innovations," was presented jointly with Steven Klepper at the 1976 meetings of the Institute of Management Science and the Operations Research Society of America. It is being revised. It traces the dif-

fusion of product innovations, defined as the increase in the number of producers of the product, over five phases. The phases, the boundaries of which are defined by discriminant analysis, consist of (1) the initial stage following commercial introduction of the product and preceding rapid "take-off," (2) the period of high growth in sales and high entry, (3) the phase of declining rate of entry as the peak in number of producers is approached, (4) the phase in which exit of firms exceeds entry, and (5) the stage associated with maturity and a plateau in number of producers.

The analysis, which was based on data developed for forty-six product innovations, resulted in a number of strong conclusions. First, contrary to the conclusions of most earlier work on entry, the number of producers reaches a peak and commences a decline while demand is still growing—indeed, frequently growing rapidly. Second, the rate of patenting is not closely related to other (and superior) indicators of the output of innovative activity. The rate of patenting moreover lags behind the rate of growth in demand by too long an interval to allow one to infer a simple causal connection between the two. Innovative activity appears to reach a peak in Stage 2, while patenting does not reach a peak rate until Stage 4 or 5.

A second paper, "Deriving the Personality Profile of a Firm from Published Panel Data," (jointly with Rao Singamsetti) has been completed and is scheduled for presentation at the Symposium on the Econometrics of Panel Data scheduled for August 1977 in Paris and sponsored by the Institut National de la Statistique et des Études Économiques. This paper, using factor analysis in conjunction with behavioral and managerial variables, successfully identifies three corporate personality profiles, namely, aggressive, risk averse, and resistant to change. The first two appear to be related to innovative behavior. Specifically, firms that introduce product innovations are shown to have more aggressive and less risk-averse profiles.

Michael Gort

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

Our paper, "Consumer Protection in Ethical Drugs," was presented to the 1976 meetings of the American Economic Association. It was published in the *American Economic Review, Papers and Proceedings,* February 1977. In the first part of our paper, we summarize the evidence for the proposition that more stringent regulation of pharmaceuticals by the Federal Drug Administration over recent years has been a major factor in the industry, leading to higher costs, time lags, and risks in pharmaceutical innovation. In the second part, we show that a significant shift has occurred in the structure of innovation in the industry: Innovation has become increasingly concentrated in the large, multinational drug firms, apparently because they are better able to bear the additional costs and risks of innovation and also because they can shift resources on a worldwide basis to offset some of the adverse impacts of regulations in this country. Some evidence concerning international transfers of technology associated with regulatory differences across countries is presented in the final part of the paper.

Our paper with Lacy Thomas, "Estimating the Effects of Regulation on Innovation: An International Comparative Analysis of the Pharmaceutical Industry," discussed in the 1976 *Annual Report,* has now been revised and submitted for publication.

Henry G. Grabowski
John M. Vernon

5. HUMAN BEHAVIOR AND SOCIAL INSTITUTIONS

Introduction

The NBER's research on human behavior and social institutions is carried on through five programs: health, income distribution and labor markets, law and economics, population and the family, and taxation and social insurance. The emphasis has been on applying economic theory and empirical analysis to a wide variety of market and non-market activities that have important implications for human welfare. In the past the bulk of the research has focused on explaining differences across individuals and families in earnings, fertility, health, and other variables, using large-scale microdata sets. Recently, there has been a moderate shift in emphasis, with some additional attention being given to the analysis of changes over time, using aggregate data. This approach has been used in some of the research on crime and health, but is most evident in the work on taxation and social insurance under Michael Boskin and in the family project, especially Robert Michael's study of divorce.

The new family project, which was launched with two-year support from the Alfred P. Sloan Foundation and the Lilly Endowment, will try to deal with some of the most pressing and fundamental problems facing our society, namely, the changes in the size, structure, character, and functions of American families. The research plan developed by Gary Becker and Robert Michael, the project directors, calls for a five-year effort which will include studies of marriage and divorce, parent-child relationships, and other aspects of household living arrangements. The goal is to increase understanding of both the causes and the consequences of recent changes in family organization. It is hoped that the early results of this project and increasing public recognition of the importance of the problem will result in additional research support.

During the past year findings from the five programs of the Center for Economic Analysis of Human Behavior and Social In-stitutions have been reported in twenty-one journal articles (published or in press) and fifteen NBER working papers. In addition, studies by several staff members appear in *The Distribution of Economic Well-Being,* an Income and Wealth volume edited by F. Thomas Juster, published this summer and in "Research on Taxation," a *Journal of Political Economy* supplement edited by Michael Boskin. Details on current research, new projects, and sources of support are provided in the following program reports.

Victor R. Fuchs

Income Distribution and Labor Markets

Introduction

More than ever before our society is concerned with variations in income and welfare among individuals and families. The research program in this area seeks to increase understanding of these phenomena by a multifaceted attack on many related factors such as labor supply, job mobility, migration, nonmarket work, and on-the-job training, as well as by detailed examination of actual earnings patterns.

The underlying theoretical models emphasize the role of human capital, broadly defined, and seek to explain behavior in a life-cycle context. The empirical work makes extensive use of large longitudinal data sets with repeated observations on the same individuals. Some of the studies give particular emphasis to the role of women in both market and nonmarket production. Others highlight black-white differentials. Some focus on mature adults; others on young people at the early stages of their careers. All contribute substantially to our knowledge of labor markets and income distribution.

Research output from this program area during the past year includes seven NBER working papers:

Ann P. Bartel and George J. Borjas. "Mid-

dle-Age Job Mobility: Its Determinants and Consequences." Working Paper 161, January 1977.

George J. Borjas and Jacob Mincer. "The Distribution of Earnings Profiles in Longitudinal Data." Working Paper 143, August 1976.

Reuben Gronau. "Who Is the Family's Main Breadwinner?—The Wife's Contribution to Full Income." Working Paper 148, September 1976.

Edward Lazear. "Family Background and Optimal Schooling Decisions." Working Paper 141, July 1976.

_____. "Intergenerational Externalities." Working Paper 145, August 1976.

_____. "Wage Differentials Are Larger Than You Think." Working Paper 168, March 1977.

Lee Lillard and Yoram Weiss. "Experience, Vintage and Time Effects in the Growth of Earnings: American Scientists, 1960–70." Working Paper 138, May 1976.

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

Reuben Gronau. "Leisure, Home Production and Work—The Theory of the Allocation of Time Revisited." *Journal of Political Economy,* October 1977. (Working Paper 137.)

Edward Lazear. "Age, Experience, and Wage Growth." *American Economic Review,* September 1976. (Working Paper 151.)

_____. "Schooling As a Wage Depressant." *Journal of Human Resources,* Spring 1977. (Working Paper 92.)

_____. "Academic Achievement and Job Performance." *American Economic Review,* March 1977.

_____. "Education: Consumption or Production?" *Journal of Political Economy,* June 1977. (Working Paper 104.)

Lee Lillard. "Inequality: Earnings Vs. Human Wealth." *American Economic Review,* March 1977.

Lee Lillard and Robert J. Willis. "Dynamic Aspects of Earnings Mobility."

Econometrica (forthcoming). (Working Paper 150.)

The center's research on income distribution and labor markets is currently supported by the National Science Foundation and the U.S. Department of Labor. Some support in previous years was provided by the Rockefeller Foundation.

Victor R. Fuchs

Labor Mobility and Earnings

In our study of the determinants of earnings in longitudinal data we moved to an intensive analysis of local job mobility and of migration in the National Longitudinal Survey (NLS) of men over 45 years of age. We also completed an analysis of the distribution of earnings profiles in the Coleman-Rossi Sample of men who were less than 40 years old at about the same time period (the late 1960s).

I. Local Job Mobility. Though less than at younger ages, substantial amounts of job mobility take place at older ages. In the NLS sample of men aged 45 to 59 in the initial (1966) survey, 22 percent of respondents changed employers in the five-year period 1966–1971. Indeed, mobility appeared to increase somewhat in the years near retirement.

The separations involving job change were about equally divided between quits and layoffs. In studying job separations we not only distinguished quits from layoffs, but also job-related quits from other types of quits (e.g., "personal reasons"). We estimated probabilities of separating from the job with and without information on job tenure and within classes of short and long tenure.

Some of the findings were:

1. Wage levels prior to separation are inversely related to quits but positively to layoffs, while the opposite appears to hold for education. All effects are weaker in "personal" quits, and the distinction between quit and layoff holds mainly in longer-term jobs (tenure of over three years). It is important to note that most separations occur in early tenure, and their nature (quit, layoff)

does not depend on the type of prior separation. These findings are consistent with hypotheses of job-sorting informational activities of workers and firms in early tenure and increasing worker specificity later on.

2. The positive relation between wages and layoff appears to be largely an industry effect. Industries with unstable employment apparently compensate workers by paying them higher wage rates.

3. Employment, earnings, and education of wives are negatively related to husbands' labor turnover. Intrafamily substitution suggests that cause and effect here work in both directions.

4. Job change resulting from quits occurs usually without intervening unemployment. However, about half of exogenous ("personal") quits and almost all layoffs involve unemployment. More than half of layoffs did not result in job change. These temporary (recall) layoffs affect primarily experienced workers, while permanent (involving job change) layoffs are largely restricted to new workers, except, of course, in the case of shutdowns. Workers temporarily laid off have personal characteristics (tenure, wage, education) much more similar to the characteristics of those who remain employed than to the people who change jobs. Temporary layoff appears to be a device to maintain a stable experienced work force in the face of unstable labor demand.

5. Persons who quit without intervening unemployment had larger immediate wage gains than stayers and than all other job movers. Quitting did not affect the subsequent wage growth on the new job. Those who quit because they were dissatisfied with their previous job had negative or zero gains in wages (relative to stayers), but they reported significant gains in job satisfaction.

II. Migration. One of the novelties of our research on migration is its emphasis on the relationship between job mobility and geographic mobility. The availability of detailed longitudinal data sets enables us to show how the determinants and consequences of an individual's decision to migrate depend on whether he quit his previous job, was laid off, or remained with the same employer. Joint and conditional probabilities of migration and separation have been estimated for the NLS Mature Men and the Coleman-Rossi Sample. Taken together, the results from several data sets will provide a life-cycle picture of the decision to migrate.

Some of the more important results derived from the NLS Mature Men data set are as follows: (1) The likelihood of an individual's migrating following a quit or transfer is positively related to the level of his education, but the likelihood of his migrating following a layoff is not related. (2) There is a positive relationship between the wife's level of education and her husband's likelihood of a job separation, but a negative one between her education and his likelihood of migrating. Hence, her level of education shows no relationship to his combined likelihood of migrating and separating. (3) The probability of migrating given a quit is negatively related to the wife's education and the presence of school-age children. These two variables have no effect, however, on the probability of migrating given a layoff. (4) Among the strongest determinants of the decision to migrate are the length of stay in the current location, and the length of job tenure.

III. The Distribution of Earnings Profiles in Longitudinal Data. The longitudinal earnings profiles in the Coleman-Rossi Sample covered the first sixteen years of work experience. On average, the estimated profiles showed the usual concavity and a great deal of variation in levels, slopes, and curvatures.

Estimates indicated that if slopes and curvatures of individual trajectories were available to analysts, an additional 20 percent of the relative variance in monthly earnings could be explained beyond the usual power provided by the cross-sectional earnings function approach. The decomposition of the slope and curvature coefficients into investment ratios and rate-of-return parameters provided a smaller increase in explanatory power because of errors introduced by the procedure.

Estimates of individual capacities within schooling groups were obtained from the residual of the schooling regression at the "overtaking stage." The results indicated that individuals with greater investment ratios grew more rapidly than others, and—holding earnings capacity constant—had lower initial earnings. It was also found that variation in earnings capacity, which is a persistent characteristic of individuals, is at least as important as variation in slopes and curvatures of earnings profiles in terms of explanatory power.

Further analysis indicated that the individual coefficients and parameters of the earnings profile are weakly, if at all, associated with individual, personal and background characteristics. The role of post-school investment parameters in earnings remains strong even after all the available personal information is utilized. Although the background variables strongly affect *educational* attainment, they show little or no relation to the personal accumulation of *post-school* human capital.

We are currently extending our work to the younger NLS cohorts in order to complete a life-cycle analysis. We are also resuming our work on the integration of labor supply functions into the analyses of earnings functions.

<div align="right">
Ann P. Bartel
George J. Borjas
Jacob Mincer
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The Allocation of Nonmarket Time

Only a relatively small fraction of people's time is spent in the form of market work. In recent years there has been an increasing interest in the way people spend the rest of their time and in the economic considerations affecting the allocation of nonmarket time.

In "Leisure, Home Production and Work—The Theory of the Allocation of Time Revisited" (due to appear in the October 1977 issue of the *Journal of Political Economy*) I try to formalize the trichotomy of work in the market, work at home, and leisure. Time is used at home to produce home goods that are perfect substitutes for market goods, where home production is subject to diminishing marginal productivity. An increase in the market wage rate is expected to reduce work at home but the effect of the increase on leisure and work in the market is indeterminate. An increase in income increases leisure, reduces work in the market, and leaves work at home unchanged. These conclusions are supported both by empirical tests based on the Michigan Income Dynamics data and by previous time budget studies. Further implications for labor supply, fertility, gains from marriage, demand for child care, and the measurement of home output are also investigated.

This work is extended in "Who is the Family's Main Breadwinner?—The Wife's Contribution to Full Income" (NBER Working Paper 148) where I try to estimate the value of the wife's home production, allowing for diminishing marginal productivity of work at home. Preliminary findings indicate that the value of home production of the American wife is about four times her earnings. Adding this value to her market earnings, she contributes, regardless of education, almost as much as her husband to the family's full income. The wife's share in the family's full income is about 45 percent, and this share comes very close to one-half when the family has young children. Needless to say, since the value of home production is not taxed, the wife's contribution to net full income (full income after taxes) exceeds that of everybody else in the family. Employed wives contribute a greater share than the not employed, but at least in the case where there are young children in the family, the difference in the contribution is small. Whether or not she is employed, the wife's share peaks early in life (by the age of 35) and drops significantly thereafter (though it may pick up somewhat in late middle age).

<div align="right">
Reuben Gronau
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Dynamics of Female Labor Supply and Wages

This research analyzes three principal problems. The first problem analyzed is the specification of dynamic labor force partici-

pation functions for women. This work generalizes previous work by Robert J. Willis and me to consider the effects of human capital and job search investments on the labor market turnover of women. The model also allows for change in explanatory variables and the effect of macroeconomic variables on labor supply. A new statistical model is proposed and estimated by which apparent state duration effects on participation due to population heterogeneity can be distinguished from the effect of human capital (or true state duration) on labor market turnover. The methodology is applicable to a wide variety of related dynamic problems of the labor force such as the effect of unemployment duration on the probability of employment. This research will be presented at the December 1977 meetings of the American Economic Association. A copy of the paper is available on request to the author.

The second problem analyzed is the specification of labor supply functions for women. A full life-cycle model of hours of work, participation, and wage growth is formulated and estimated.

The third problem analyzed is the specification of the wage dynamics of women. A more careful analysis of the wage growth of women reveals that previous work substantially overstates the effect of labor market experience in reconciling male-female wage differentials.

James J. Heckman

Family Considerations in the Determination of Earnings

This year was spent working primarily on three papers: "Family Background and Optimal Schooling Decisions," "Intergenerational Externalities," and "Wage Differentials Are Larger Than You Think" (NBER Working Papers 141, 145, and 168, respectively).

The first paper is an attempt to determine whether or not capital markets for the financing of schooling are perfect and invariant across groups. Because attained levels of schooling are positively correlated with income, some researchers have suggested that the ability to finance the acquisition of education internally tends to perpetuate schooling and income inequalities across generations. Capital cost differences, it is argued, may be a crucial variable in the explanation of education and income variations. Using the model presented in this paper, capital cost differences can be tested across income groups. Other things constant, no evidence of any difference was found.

The second issue dealt with in the family background paper relates to optimization. Even if capital costs do not differ across income groups, information about costs and returns to education may. The differences in information among individuals may themselves well be optimal, given differential costs and returns to the information. This will appear as a larger variance around the "perfect information optimum" level of education for less-informed groups. That is, all things considered (including information), observed variations in schooling levels should be optimal. It is interesting to ask, however, how variations in schooling levels would look in a setup where all possessed the same amount of ex-post information on costs and returns to schooling. The model provides an answer to this question as well. It is found that groups for which the marginal returns to schooling are low also have larger variances in the difference between actual and predicted optimal levels of schooling. This is consistent with the observation that low-wage groups invest a smaller amount in information than high-wage ones. The finding therefore makes sense. Individuals should optimally acquire more education when both the returns to being correct and the costs of making a mistake are high.

The model is constructed to allow estimation of returns to education for each individual, based on the assumption that all individuals face the same borrowing rates. Given costs and returns, an optimal wealth-maximizing level of education can be obtained for each individual. Differences between actually acquired and wealth-maximizing levels of education can then be

calculated and it can be determined whether or not these residuals are systematically related to background variables. If, for example, the estimated wealth-maximizing level of education of low-income individuals is consistently larger than the actual level, it could be concluded either that returns to schooling differ between groups or that capital market differences exist. The model allows these two explanations to be distinguished. Since differential returns are caused by wage differences among groups, the wealth-maximizing level can take these labor market variations into account.

Data from the National Longitudinal Survey (1966–1969) on young men who were no longer in school have been used to test the theoretical predictions of the model. Empirical findings are:

1. It appears that there is no discrimination among particular groups with given endowments either via capital market mechanisms or governmental provision of schooling.
2. The average marginal cost and return to a year of schooling is about $7,000 in current terms. For nonwhites, it is only about $5,700.
3. The value of schooling is more elastic with respect to measured IQ than to mother's education.
4. The elasticity of schooling with respect to marginal cost is, at the point of means, −1.8. It would require a subsidy of $318 to induce the mean individual to attend school for one more year.
5. Estimated wealth-maximizing and actual levels of education vary positively with mother's education and IQ and negatively with family size. Other things constant, actual and predicted wealth-maximizing levels of education are higher for nonwhites than for whites.
6. If nonwhites faced the same labor market conditions as whites, their attained schooling levels would be lower than they actually are because the average levels of other endowment variables are relatively lower for nonwhites.

In "Intergenerational Externalities," a new dimension is brought into the analysis. Up to this point it has been assumed that personal optimization is the only relevant issue; that is, human capital models and the type of model used in "Family Background and Optimal Schooling Decisions" are designed to maximize the wealth of the individual. In this second paper, the analysis is extended by recognizing that the individual is a member of a family and that his wealth depends in large part on what his parents do for themselves and for him directly. Optimization is considered from a social point of view, and an investment is said to be socially optimal if all parties involved reap returns which exceed the cost of that investment. Specifically, the problem taken up is that parents sometimes underinvest in their children's health, education, and general welfare as the result of an intergenerational externality. If the parent does not fully take his child's preferences into account, and if the child cannot, through contract, insure repayment to his parents, then it is likely there will be a deviation between the socially optimal amount of investment in that child and the privately optimal amount. Through a model of general human capital stock which maximizes the discounted value of wealth over all generations, it can be shown that the socially optimal level of parents' investment in the human capital of their children is greater than the privately optimal one. The theoretical framework is used to estimate the size of these intergenerational externalities.

The data used in this analysis come from the Michigan Income Dynamics Panel Study on 1,455 heads of households. From these data, one can ascertain the extent to which parents underinvest in their own education because they fail to consider spillovers to their children. The results show that although all groups may tend to underinvest from the socially optimal viewpoint, the distribution of underinvestment is not uniform across groups. Low-income, and especially black, men are more likely to underinvest in their education from a social point of view

than are whites and wealthier individuals. Note the difference between this finding and the one in the first paper, where it is argued that private optimization across individuals does not result in there being different levels of schooling as the result of different borrowing costs. In the second paper it is assumed that private markets are efficient. The result of the first paper is taken for granted, but it is then argued that, given that efficient market, deviations between social and private optima vary across groups. It is estimated that a subsidy of $9,600 would be required to induce the average black man to invest in the socially optimal level of education if none of the intergenerational spillover effects from parents are considered.

The rest of the past year was spent on an analysis which takes into account the effect of family background on the measurement of wage rates. Specifically, this research, reported in NBER Working Paper 168, investigates wage differentials between black and white workers, where wages are defined to include the on-the-job training component of earnings. This unobserved component can be estimated by looking at the capitalized value of wage growth.

Using data from the National Longitudinal Survey on young men aged 14–24 in 1966, it was found that the normally measured wage differential was 58 cents per hour. The "true" differential, which includes the capitalized value of wage growth, was almost three times as large. About two-thirds of the unobserved and one-half of the total wage differential could be eliminated by bringing the average level of blacks' schooling, currently at about 10 years, to that for whites, at about 11.5 years. This result is obtained primarily because on-the-job training seems to be complementary with level of schooling attainment. Hence, other things equal, highly schooled individuals have steeper age-earnings profiles.

By using the National Longitudinal Survey of the high school class of 1972, true wage differentials in 1972 can be compared with those obtained from the 1966 survey. The most important finding is that the narrowing of black-white wage differentials in

pecuniary terms which occurred between 1966 and 1972 was almost exactly offset by an increased differential in on-the-job training. Thus it appears that employers have responded to pressure to narrow wage differentials by increasing differentials in a form of payment that is more difficult to observe.

Edward P. Lazear

Earnings and Occupational Prestige over the Life Cycle

This research considers the lifetime pattern of earnings and occupational prestige. It examines both the effect on lifetime patterns of schooling, ability, and family background differences and the degree to which individuals differ permanently, over a 25-year period, in earnings and occupational prestige. It also considers the implications of these sources of earnings variation for inequality in human wealth, defined as the present value of lifetime earnings. Many of the results for earnings are summarized in "Inequality: Earnings Versus Human Wealth." A more complete analysis is provided in "An Essay On Human Wealth," and the results were summarized in last year's report. Some new results are summarized in "Earnings and Occupational Prestige over the Life Cycle," in which several novel issues can be addressed owing to the availability of longitudinal data. First, the ex-post lifetime patterns of occupational prestige and earnings are compared for men from the U.S. birth cohorts of 1917–1925. The lifetime patterns of each are influenced in different ways by years of schooling completed, measured IQ-type ability, and early family background. Second, individual earnings and occupational prestige are affected by some characteristics the researcher is unable to observe. I estimate permanent, transitory, and serially correlated components of the variation of earnings and prestige, each net of the predicted lifetime profiles. Individuals who are observationally identical are found to have important unmeasured permanent and serially correlated residual components in prestige as well as earnings. To put the

issue slightly differently, I address the issue of the strength and sign of the correlation of earnings and prestige residuals among individuals observed repeatedly over a period as long as twenty-five years. As expected, the correlation for both earnings and prestige is a declining function of the time distance between two observed years or points in the life cycle. However, the correlation is always strongly positive, even after twenty-five years.

The existence of these important individual differences among observationally identical individuals raises the following third issue. Are those individual earnings and prestige differences positively or negatively correlated? That is, if an individual is observed as permanently above the lifetime earnings profile predicted for individuals observationally like him, is he likely to be permanently above or below the corresponding lifetime prestige profile? I find substantial positive correlation. Hence, deviations from estimated profiles are not compensatory.

A similar issue relates to transitory earnings and prestige deviation, which are themselves serially correlated. If an individual is transitorily shocked above (below) his own projected profile, is his occupational prestige more likely to be shocked in the same direction or in the opposite direction? Again I find a positive correlation. These across-equation results must, however, be interpreted with caution, since occupation may signify more than simply prestige. These are two reduced form equations among many which might be developed with respect to occupations.

Lee A. Lillard

A Study of Earnings Dynamics

In the past year our research has focused on the development and implementation of an econometric methodology that may serve as a link between theory and panel data on several dynamic aspects of labor market behavior. The issues we address jointly and individually in various subject areas include (1) dynamic aspects of earnings distributions and poverty analysis, (2) simultaneous estimation of long- and short-run labor supply elasticities, (3) the role of hours and wages in earnings variation over time, and (4) covariation over time in the earnings of husbands and wives in two-earner families. We will discuss these in turn.

In the first study, "Dynamic Aspects of Earnings Mobility" (NBER Working Paper 150), the econometric methodology for the analysis of earnings mobility is used to determine whether poverty is a transitory or permanent condition of individuals. It has the advantage of providing a direct link between traditional human capital theory, earnings functions, and Markov chain type models. The methodology is fairly simple. First, we estimate an earnings function with male earnings as the dependent variable, using the seven years of panel data. We estimate permanent, transitory, and serially correlated components of earnings due to both measured and unmeasured variables. Measured variables are represented by components of variance. The estimated earnings function and the estimated components are then used to compute the probability that an individual's earnings will fall into a particular, but arbitrary time sequence of discrete earnings classes. For simplicity, we focus on the probability that an individual's earnings fall below an arbitrary poverty line defined as one-half of median U.S. male earnings each year, 1967–1973. With these techniques, indexes of income immobility or the degree of "persistence" in individual income levels are developed for various subgroups of the population (e.g., by race, experience, and education). Such measures include the proportion of earnings variation (gross variation or variation around a predicted level) among individuals, which represents a permanent difference; the degree to which earnings are correlated from year to year for the same individual; and the rate of decay of correlation around the permanent level.

Analysis of the variance components of the log of annual earnings of men (in 1970 dollars) indicates that 73 percent of total variance in log earnings represents permanent earnings differences. The

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remaining transitory earnings variation is serially correlated, with a coefficient of 0.4. The magnitudes of these earnings variance components have important implications for the study of poverty and the stability of the poverty population.

These points are illustrated by considering the poverty dynamics of blacks. Using our definition of poverty, about 14 percent of blacks were predicted to be in poverty in 1967. Of those who were in poverty in 1967, 65 percent were expected to be in poverty in 1968, while of those not in poverty in 1967, only 4 percent were predicted to be in poverty in 1968. The importance of permanent earnings components is illustrated by the persistence of these effects. For example, of those in poverty in 1967, the probability of poverty in 1973 is 44 percent, while of those not in poverty in 1967, the probability of poverty in 1973 is less than 3 percent.

The second issue is the development of the previous earnings model from an underlying dynamic labor supply function in which permanent, transitory, and serially correlated variations in an individual's (log) wages induce long- and short-run labor supply responses. An analysis of covariation over time of (log) annual hours and (log) earnings in panel data yields estimates of both the long- and short-run labor supply elasticities.

This earnings model in turn provides the basis for studying the third issue, the role of hours and wages in the variation of earnings over time. For example, not only can we decompose cross-sectional earnings variance into permanent and transitory parts, but we can also determine the extent to which exogenous wage variation, exogenous hours variation, and induced hours variation are responsible for permanent and transitory variation in earnings. The intertemporal distribution of earnings will be examined by calculating predicted and actual transition probabilities among discrete earnings classes defined both in relative and absolute terms.

The above earnings analysis is used for both husbands and wives in the final study topic, in which the emphasis is on a comparison of permanent versus single-period earnings inequality among families and the role of within-family variation for two-earner families. The objective is to discover whether husband's and wife's earnings are compensatory or not. Given that both of them work throughout the period, we analyze the correlation between both the permanent and transitory earnings of each. If the aim of couples is a combined family income of a certain level, then permanent earnings of pairs will be negatively related and compensating and family incomes will be less unequally distributed than, say, husband's earnings. If the two permanent earnings components are positively related, then inequality among family incomes will be even greater than among husband's earnings. Also transitory variation in the earnings of one spouse may induce a response by the other. Hence, the dynamic labor supply model can be developed to include both husband and wife.

Lee A. Lillard
Robert J. Willis

The Effect of Minimum Wage Legislation on Income Equality

While at the Bureau I have corrected, extended, and rewritten for journal publication an earlier paper of mine on the theoretical effect of a minimum wage law on income equality under a variety of assumptions. A one-sector model of general equilibrium is used to analyze a universally applicable minimum wage, and a two-sector model is used to analyze a minimum wage that is only applied to certain industries. In both cases I find that a minimum wage may well lower equality (as computed by the Gini index) if we consider reasonable values for the parameters of these two models. In the absence of unemployment compensation, equality can increase only if the elasticity of substitution in production is quite low. In the one-sector case, however, equality necessarily rises if unemployment compensation is present and sufficiently generous.

J. Huston McCulloch

Population and Family Economics

Family Economics

During the past year much of the Center's work on family economics has been refocused under a new several-year project, "Change and Stability in the American Family." The co-directors are Gary Becker and Robert Michael and the staff includes Victor Fuchs, Reuben Gronau, and Edward Lazear. Larry Kenny, from the University of Florida, will join the project as a visiting scholar for the 1977–1978 year and other additions to the staff are expected. The project is funded by grants from the Alfred P. Sloan Foundation and the Lilly Endowment, Inc.

The project is motivated in part by the profound changes in recent years in several aspects of family behavior—the well-publicized decline in fertility, the rise in women's labor force participation, the rise in age at marriage, and the increase in divorce rates. It is also motivated in part by our assessment that it is an appropriate time to apply to time series behavior the insights obtained from cross-sectional studies of family behavior. In addition to extending the analytical work on the family conducted at NBER and elsewhere in recent years, we expect the project to enrich descriptive information about the nature of recent changes in the family.

One objective of the project will be to assess the advantages to adults of living in the context of a family. Despite the rise in divorce rates and median age at first marriage, it appears that a vast majority of individuals still choose to spend a dominant portion of their adulthood in a family. Presumably this form of living arrangement is chosen because of its value to the individual, and we intend to estimate the magnitude of some of the benefits of living in a family and consider how these benefits may be changing in the context of developments in social customs and government policy. In one study Kenny will attempt to measure the impact of family status on the labor market productivity of men, using longitudinal data. In another, Lazear and Michael are attempt-

ing to measure the economies of scale in consumption attributable to family size. Differences in health status and perhaps nutritional adequacy of diets also appear to reflect an advantage of family membership, and the project may involve studies of these facets as well.

The concept of "family," the relationship between it and other multiperson living arrangements, the various social functions performed by it, and the changes in these functions over time and across societies will be explored by Becker. The bearing and raising of children represent one of the important aspects of family behavior, and we expect to include several studies on children in this project. For example, Lazear is beginning a study on differential expenditures on children within families, designed in part to indicate whether parents tend to reinforce or compensate for differences among their children in ability, health, and the like.

A second focus of the project will be on the relationship between the family and the distribution of income. In this area the studies we expect to undertake include the work on economies of scale, mentioned above, the interaction between the labor supply of husbands and wives, and the changes over time and differences between the distributions of income when defined among earners or among all individuals and when defined among families or among families and "unrelated individuals."

The staff will engage in several essentially descriptive analyses, attempting to document better the changes and stability in postwar family behavior and their causes and repercussions. One such effort, for example, involves the construction from vital statistics data of the fractions of 18-year-olds in each year who were first-born children, second-born children, etc.—a set of time series which are, of course, affected by the baby boom but which contain a quite different time pattern. Another time series is an estimate of the fraction of adult lifetime spent living outside any family. We hope that the set of series under construction will provide more economically meaningful in-

formation about relevant changes taking place and will also be usable in subsequent statistical time series analyses. Fuchs and Michael are currently beginning this work on "family accounting."

By way of an update on the previous year's reports on the study of divorce, two NBER working papers were completed this past year: Michael's "Factors Affecting Divorce: A Study of the Terman Sample" (no. 147, August 1976) and Becker, Landes, and Michael's "Economics of Marital Instability" (no. 153, October 1976). Michael is currently engaged in a time series analysis of U.S. divorce rates over the period 1920–1975. The findings to date suggest that about two-thirds of the rise in divorce in the 1960s was among couples in which the woman was in her twenties. The change in contraceptive technology appears to be the single most important "cause" of the recent rise in divorce, but the rise in women's labor force participation does not seem to be a major determinant of that increase.

Robert T. Michael

Population Economics

The program in population economics, under my direction, includes a number of research activities that are complementary to the family economics program. These complementarities are especially apparent in research supported by the Ford Foundation and the U.S. Agency for International Development (USAID) concerning economic and demographic aspects of family behavior in less developed countries. In theoretical work in progress, I am investigating the role of the family as an economic institution in situations in which other private and governmental institutions are poorly developed. A major goal of this work is to investigate the implications of the hypothesis that children are "the poor man's capital" (Mahmood Mamdani, *The Myth of Population Control: Family, Caste and Class in an Indian Village*, New York, Monthly Review Press, 1972)—a source of labor, of security, and of old-age support—for fertility behavior, saving, investment, and other

aspects of household behavior, and for the development of economic activities in organized markets.

Several empirical studies of household economic and demographic behavior using microsurvey data from several developing countries are under way or planned for the coming year. A preliminary draft of an empirical study, "Sharecropping and Family Size in the Brazilian Northeast," has been completed by Anna Luiza Ozorio de Almeida, who was a visiting scholar at NBER in Palo Alto from the National Institute of Economic and Social Research (INPES-IPEA) in Rio de Janeiro. Reuben Gronau is working out a procedure for measuring the value of nonmarket time in developing countries, and I am planning a study of life-cycle aspects of fertility and female allocation of time, using survey data from Guatemala.

Robert J. Willis

Law and Economics

Introduction

The research activity during the past year included the following studies: Isaac Ehrlich's continued cross-sectional and time series analysis of deterrence and capital punishment in the United States; Kenneth Wolpin's study of crime in England and Wales from 1894 to 1967; William Landes's work on the deterrence of skyjacking; Landes and Richard Posner's continued and expanded work on legal precedent and their new study of the law and economics of rescue; Posner's study of the economics of contracts; B. Peter Pashigian's work on the market for lawyers and his new study of the effects of occupational licensing; and Sam Peltzman's study of industrial concentration and profitability and his new study of the size of governments. Eight journal articles were published this year (including one by Posner on the legal rights of creditors and another by Peltzman on regulation that were described in detail in last year's report) or will be published shortly—*Journal of Law & Economics* (3), *Journal of Legal Studies* (2), *American Economic Review* (1), *Journal of*

Political Economy (1), and *University of Chicago Law Review* (1).

The law and economics program is supported by grants from the National Science Foundation and the American Bar Foundation, which supports Pashigian's research on the legal profession.

William M. Landes

Studies on Punishment and Deterrence

During the past year I completed the following papers, which were subsequently published:

"The Deterrent Effect of Capital Punishment—A Reply." *American Economic Review*, June 1977.

"On the Measurement of the Deterrent Effect of Capital Punishment and the Theory of Deterrence." *Journal of Legal Studies*, January 1977.

"Capital Punishment and Deterrence; Some Further Thoughts and Additional Evidence." *Journal of Political Economy*, August 1977.

My monograph, tentatively titled "A Matter of Life and Death: Essays in the Economics of Crime and Deterrence," is progressing. The book will contain five chapters plus an introduction and a concluding chapter. In the introduction I view the work on deterrence in a historical perspective, with references to previous work by classical economists and the utilitarian school, and I analyze the challenge to the original work of economists advanced by other social sciences, starting in the late nineteenth century. In Chapter 1, I review past literature on deterrence by criminologists who placed a major emphasis on the deterrent effect of capital punishment. Chapter 2 contains my earlier paper, "Participation in Illegitimate Activities. An Economic Analysis," (originally published in the *Journal of Political Economy*), and Chapter 3 contains "The Deterrent Effect of Capital Punishment—A Question of Life and Death" (published in the *American Economic Review*). Chapter 4 includes my new cross-sectional study of capital punishment and deterrence, which is scheduled for publication in the *JPE*, sup-

plemented by additional theoretical work on optimal enforcement of sanctions and a discussion of trends in the application of the death penalty. Chapter 5 contains most of the work still in progress. It deals with the pooling of time series and cross-sectional data on murder and other crimes, the simultaneity of offense and defense, a study of the effect of killings through police intervention, and analysis of demographic factors.

Isaac Ehrlich

Skyjacking and Deterrence

In this study I attempt to estimate the responsiveness of airline hijackings to various deterrence measures (e.g., the probability of apprehension, the conditional probability of conviction, and the length of the sentence) and economic variables (e.g., the unemployment rate) from time series data on commercial airline hijackings in the Unites States and foreign countries since 1961. I also seek to estimate the factors affecting the probability of apprehension and to assess the costs and benefits from specific procedures such as the sky marshal program in 1970–1973 and the mandatory search of passengers that was begun in 1973. The data used for the study are individual hijackings that include information on the hijacking (time, place, type of plane, destination), the characteristics of the hijackers (age, sex, race, number of persons involved), and the outcome, including information on the disposition of each defendant. Preliminary results show significant deterrent effects on the frequency of hijackings of the various deterrence variables, and a positive effect on hijackings of unemployment. These findings are based on both a quarterly time series regression analysis of the U.S. data and a disaggregated analysis in which the frequency of hijackings is estimated by the time interval between their successive occurrences.

William M. Landes

Economic Analysis of Legal Precedent

A legal precedent is a previous decision that is relied upon as a basis for deciding a

subsequent case. From an economic standpoint, the body of precedents created by judicial decisions in prior periods is a stock of capital that yields a flow of information services which depreciates over time as new conditions arise that were not foreseen by the framers of the existing precedents. New capital is created by investment in the production of precedents. A capital theory approach to legal precedent yields testable implications on the relationships among investment, depreciation, and the capital stock, and provides a basic framework for collecting and organizing a great deal of data on precedent. The basic data are case citations appearing in judicial opinions and estimates of investment based on published judicial opinions in various substantive areas of the law. These data make it possible to estimate depreciation rates, investment, and the capital stock of precedents in various areas. These estimates, in turn, can be combined with other legal, social, and economic data and used to examine a wide range of questions, as illustrated by the following examples.

1. Has the role of precedent in legal decision-making declined, as many observers believe, over the last 100 years?
2. Did judicial activism, associated with the "Warren Court" in the 1960s, lead to a faster rate of depreciation and a destruction of legal capital?
3. Do areas of the law with relatively large amounts of statutory activity have higher depreciation rates and lower amounts of judicial capital?
4. Does a new statute lead to a depreciation of legal capital?
5. What is the relationship between the age-earnings profiles of lawyers and the depreciation rate of legal capital?
6. What is the relationship between the amount of lower-court litigation, the rate of investment in precedent, and depreciation?
7. Does the size of the capital stock and depreciation differ systematically between higher and lower courts? Federal and state courts? Federal administrative agencies and federal courts?

Although these issues have received little systematic analysis, their clarification is central to an understanding of the legal system and, ultimately, the relationship between the legal and economics systems. We have completed the first of several planned studies on legal precedent. Our initial study, which was described in detail in last year's annual report and published in the *Journal of Law & Economics* (August 1976), was based on a sample of 658 federal court of appeals decisions in 1974–1975 and a sample of 156 U.S. Supreme Court cases during the 1974 term. Our on-going study is based on a sample of about seven thousand federal court of appeals decisions from 1892 to 1976, and a sample of about a thousand Illinois appellate court cases from 1970 to 1976. In addition, we are planning in future studies to develop data on precedent utilization in a federal administrative agency and possibly for a foreign country.

William M. Landes
Richard A. Posner

The Law and Economics of Rescue

We use the term "rescue" to cover all attempts to preserve the safety of a person or property, other than pursuant to a contract. A synonym for rescue in this sense is "unbargained assistance." Some examples will illustrate the variety of settings in which a question of rescue may arise.

1. A physician renders medical assistance to a person lying unconscious in the street. Can the physician collect for the services rendered?
2. The master of a ship, in order to prevent it from sinking in a storm, jettisons some of the cargo. Is the owner of the jettisoned cargo entitled to any reimbursement by the shipowner or other owners of cargo?
3. A ship tows a stranded ship to safety. Is the rescuer entitled to a reward for his efforts from the owners of the ship and cargo he saved?
4. A drowning man cries for help, a strong swimmer ignores his cries, and he drowns. Is the decedent's estate entitled to damages from the swimmer?

5. A man loses a wallet and posts a reward. Someone finds the wallet, returns it, and claims the reward, but the owner refuses to pay. Has the finder a cause of action against the owner?

The central feature of all these examples is the existence of high transaction costs that precludes the voluntary negotiation of rescue contracts. Thus, in each of these examples (except 4), if the rescuer were successful and later claimed a reward, his claim could not be rejected on the ground that, had the rescue been a value-maximizing exchange, the victim and rescuer would have agreed in advance on the terms of the compensation. In the first part of our study we develop a model of a competitive market in rescues where transaction costs are assumed to be zero. Although our primary interest is rescue situations where transaction costs are prohibitive, the competitive model can be used to predict what legal rules will emerge (assuming the legal system in this area is concerned with promoting efficiency), and as a benchmark for evaluating the observed legal rules. The model adds a new element to the economic analysis of the legal system by incorporating the possibility of altruistic action, an important factor in rescues and one that may significantly affect the choice of legal doctrines to maximize efficiency in this area.

In the second part of the study we will apply the model to a variety of specific legal problems along the lines suggested by the above examples. The principal doctrines we plan to analyze are the admiralty doctrines of general average, salvage, and abandonment; the principles of the law of restitution governing the conferral of benefits in cases of emergency or incapacity; common law and statutory regulation of finders of lost or mislaid property; the Good Samaritan (no-duty) doctrine and its exceptions; and the legal liability of rescuers.

We have found extensive published data on salvage awards, from the eighteenth century to the present, made in admiralty courts in the United States and Great Britain. The data include the size of awards, the

value of property saved, the capital involved in the rescue, the amount of time involved in the rescue, the type of rescue operations, etc. We plan to use these data to test the hypothesis that the actual setting of salvage awards is an attempt to simulate the conditions and outcomes of a competitive market.

William M. Landes
Richard A. Posner

The Demand and Supply of Lawyers

During the past year, I have expanded the time series study of the demand and supply of lawyers. During the last fifty years, the legal profession has experienced two extended periods when the rate of return to legal education was relatively high. The first period covers the 1920s and the early 1930s and the second extends from the 1960s into the first half of the 1970s. Some tentative explanations of the length of these prosperous periods are investigated. The time series evidence indicates real national product is the major determinant of the number of lawyers. Other less important determinants are the divorce rate and the number of court cases. As expected, the number of lawyers appears to decline with increases in alternative earnings and opportunities.

Historical trends on the lawyer-population ratios in Canada, England, and the United States show higher lawyer intensity in the United States than in Canada and England throughout the period from 1920 to 1970 and cast doubt on the importance of regulation as a determinant of demand. While the number of lawyers is directly related to the number of federal district court cases commenced, it is not related to the combined budgets of fifteen regulatory agencies.

The results of the study are reported in NBER Working Paper 158 and will appear in a forthcoming issue of the *Journal of Law & Economics*.

B. Peter Pashigian

The Effect of Occupational Licensing of Professionals on Interstate Mobility

I have begun a study on the effects of licensing and reciprocity on interstate mo-

bility of professionals with particular emphasis on the legal profession. The interstate mobility rate of lawyers may be low because of (1) the bar examination and limitations on reciprocity or (2) investments in state law and procedure undertaken during law school or during practice. Some preliminary results have been obtained in a study of thirty-four professional occupations composed primarily of male workers with high educational attainment. Occupations without licensing are compared with licensed occupations with reciprocity and those with little reciprocity. Licensed occupations with reciprocity have lower mobility rates than unlicensed ones. Limitations on reciprocity reduce interstate mobility of human capital still more.

If state-specific law is taught in law schools, it should be reflected in a low interstate mobility rate for law professors. However, the interstate mobility rate of law professors is relatively high and similar to the rates of professors in other fields. If investments in state-specific law are undertaken through practice, the interstate mobility rate of lawyers should decline more rapidly with age than the rates of those in other occupations. However, it does not appear to do so after controlling for the effects of private practice.

B. Peter Pashigian

The Gains and Losses from Industrial Concentration

The positive relationship between industry profitability and concentration is one of the more durable empirical regularities in the industrial organization and antitrust literature. Most analysts interpret the relationship as implying supercompetitive prices in concentrated industries; others argue that it reflects the costs of unusually efficient firms which come to dominate concentrated industries. In my study, I try to sort out these contentions empirically. I examine changes in prices, costs, and concentration in 165 four-digit SIC industries. A model is developed in which price changes reflect cost changes and concentration changes, but in which cost changes can

also be affected by concentration changes. The principal empirical finding is that holding cost changes constant, prices rise more where concentration increases, but that costs fall where concentration increases. The second effect dominates the first; hence, on balance, prices fall when concentration increases.

These findings imply that legal hostility toward concentration may have been misguided by the traditional view that concentration is solely an index of collusion costs. The magnitudes of the effects I have estimated imply that a vigorous anti-concentration policy can be expected to have a net resource cost of several billion dollars per year. This paper is available as an NBER Working Paper 163 and will be published in the *Journal of Law & Economics*.

Sam Peltzman

The Size of Government

For most of the twentieth century, an increasing share of national income has been channeled through government spending almost everywhere in the world. In addition, government policies (e.g., regulation) appear to have had an increasing impact on nongovernment spending, though this impact is difficult to measure satisfactorily. To some extent, this growth of government may reflect growth of demand for public goods. However, this is unlikely to be the whole story. The rapid growth in direct transfers and subsidies for private goods suggests that distributive goals have significantly affected the political process. This project will attempt to establish what these distributive goals are and how far they take us in explaining the growth and size of government.

The underlying assumption of the study is that the political process will be pushed toward establishing a "politically efficient" distribution of wealth, i.e., one that either maximizes the power and security of current officeholders, or, more simply, dominates in the competition for office. The hypothesis to be tested is that government's role in the economy is larger when more wealth has to

be redistributed to attain the politically efficient distribution. This leads to an expected relationship between the actual distribution of income and the growth of government, with government spending motivated by discrepancies between the actual and efficient distribution.

The study is at a preliminary stage in which the model is being developed and the most easily accessible income distribution and government spending data (states of the United States) are being processed. The model has so far distinguished two ways in which existing income distributions can affect the growth of government. First, if a few individuals get a large fraction of total income, there will be political gains to taxing them. But less obvious, government may thrive where some forms of equality are increased. For example, the development of a numerically large group with similar incomes makes it attractive to spread the scope of government and also its size.

I intend to develop the model more fully to account for the role of· education (and inequality in education) and, if the preliminary empirical work is encouraging, I will apply the analysis to a variety of historical and cross-sectional data.

Sam Peltzman

Economic Analysis of Contracts

During this past year, I completed a paper with Andrew Rosenfield that analyzes impossibility and related doctrines in the law of contracts from an economic standpoint. The paper appeared in the *Journal of Legal Studies,* January 1977. The defense of "impossibility" allows a contract promisor, in some circumstances, to excuse his failure to complete performance of the contract. Death and war are examples of circumstances that have been used to excuse contract performance on this ground.

Our study examines judicial doctrines and the outcomes of reported cases to determine whether the courts excuse contract performance where (and only where) the result is efficiency-enhancing because the promisee is the superior risk bearer in the (economic) sense in which we define this

concept. We find that on the whole the courts do employ an implicit economic logic in deciding these cases.

We are now collecting form contracts (printed in all states) in order to conduct a more systematic empirical analysis of the economic properties of the impossibility doctrine and other doctrines in contract law. Contracting parties can by express agreement normally override a judicial rule of contract law. Accordingly, where states differ in the judicial rule, we would expect contracts in states that have rejected the efficiency rule to waive its application. This is. the hypothesis that we hope to test by collecting and examining the form contracts printed in the various states.

I am also working on a study of so-called gratuitous promises. I seek to give an economic explanation for such promises and to determine whether the courts enforce them when economic theory indicates that enforcement would enhance efficiency.

Richard A. Posner

An Analysis of Crime in England and Wales: 1894–1967

I have recently completed a manuscript on crime and punishment in England and Wales, spanning the period 1894–1967. The purpose of this research has been to gain further understanding of criminal behavior and sanctions. Using a model of optimal law enforcement, I attempt to explain the movements over time, both within and between specific types of offenses, of variables that are under societal control. The time series pattern that emerges is as follows: The proportion of crimes cleared and the proportion of convictions leading to imprisonment have fallen, the latter quite dramatically; actual time served has remained roughly constant; and conviction rates have risen. As between crimes, the time series generally show that the more serious crimes entail greater risk of capture and more severe penalties. Most of these observations are shown to be consistent with the economic framework.

In the second part of the paper, the response elasticities of offenses to changes in the law enforcement variables are esti-

mated in a regression framework. After controlling for several demographic and economic characteristics (e.g., unemployment and urbanization), negative relationships are found between the law enforcement variables described above and offense rates. An attempt is made to isolate the deterrent from the incapacitation effect of imprisonment. One approach is to compare the effect on crime of a noncustodial penalty (e.g., recognizance) relative to imprisonment. Since the former does not incapacitate, its sole effect must be as a deterrent and since it is a less severe penalty, it must deter less than imprisonment. As a lower bound, it is found that, depending upon the specific crimes considered, the deterrent effect of imprisonment is as large as 70 percent of the total effect.

An alternative approach to separating deterrence from incapacitation is based on the proposition that unanticipated changes in law enforcement variables can only have incapacitation effects. Assuming that the forecast of a variable is based only on the past behavior of that variable, estimates of unanticipated changes are obtained using time series methods. Preliminary results have been somewhat ambiguous, sometimes yielding smaller deterrent effects than the first method. I am now making partial corrections for the omission of other variables that may be relevant to the formation of anticipations.

Kenneth I. Wolpin

Taxation and Social Insurance

Introduction

The program on the economics of taxation and social insurance is now entering its second year. Research on taxation continues to be funded by a grant from the U.S. Treasury Department. A major effort in the study of many aspects of social insurance began in July with the award of a contract from the Department of Health, Education and Welfare. The award supported a workshop on social insurance, which was held at the Palo Alto office of the Bureau in January and was attended by fifty

economists working in this field. Eight progress reports were presented for discussion, in addition to informal discussion of their current work by most participants.

Taxation

Work in the taxation field included the (forthcoming) publication of my paper "Taxation, Saving and the Rate of Interest," in the *Journal of Political Economy* this year and the presentation of my paper, "Optimal Tax Theory, Econometric Evidence, and Tax Policy" (NBER Working Paper 152) at the International Economics Association Conference on Contributions of Econometrics to Public Policy, held in September 1976. In the latter paper, attention is drawn to the implications for tax structure of different labor supply elasticities among primary and secondary earners in households and of the interest elasticity of saving.

Joseph Stiglitz and I presented "Some Lessons from the New Public Finance" at the American Economic Association convention in September, 1976; the paper was published in the *American Economic Review, Papers and Proceedings,* February 1977. In that paper we summarized recent advances in public finance and their relationship to traditional theory, including the way it has been misapplied in second-best situations. We showed the application of an optimal taxation framework to the analysis of tax credits and deductions.

Eytan Sheshinski and I are working on the tax treatment of the family, analyzing a variety of efficiency and equity aspects of alternate ways of treating the family. The effect of taxation on the labor supply of husbands and wives is one of these. Another aspect is the design of optimal tax treatment when the bivariate distribution of the ability of husbands and wives is taken into account. We are also looking at the design of appropriate tax exemptions and credits for family size with regard to equivalent consumption scales.

In the study of the effects of taxation of human capital, I am now finishing two pieces of work. One is a theoretical analysis of the optimal tax treatment of physical

capital under alternate constraints on the tax treatment of human capital. The other is an empirical examination of the effects of taxes on human investment, using U.S. time series data.

Social Insurance

In the social insurance area, the data from the first four years of the Social Security Administration's Retirement History Survey have just been received; we are now working on a wide-ranging study of the economic behavior of the aged. One major question being examined with the help of these data is the effect of social security on the labor supply of the elderly. Another topic under study is the pattern of income and expenditures of the elderly. The aim of this examination is to obtain a more accurate and complete picture of their economic welfare. Michael Hurd, Martin Feldstein, Sherwin Rosen, Lee Lillard, and I are among those working on aspects of this study.

Michael Hurd and I are working on the measurement of the labor supply response. We are using cross-sectional and panel data for preretirement and retirement age individuals to measure this and have delineated the sources of potential bias arising from each kind of data. My earlier paper, "Social Security and Retirement Decisions," in which I develop a suitable regression technique and apply it to a subsample of the University of Michigan's Panel Study of Income Dynamics, has now been published in *Economic Inquiry,* January 1977. Our current work on early retirement embodies both methodological and data improvements. The analytical method focuses on the probability of early retirement between the years 1969 and 1971 as a function of several variables, including parameters of the Social Security system.

Eytan Sheshinski, Jerry Green, John Shoven, and I are developing an appropriately realistic model to explore implications for the economy of changing population patterns, with special reference to their effects on public income maintenance and social insurance programs. Among the features important for such a model are indi-

vidual lifetimes composed of four distinct and variable-length periods, a nonhomogeneous labor supply, and the existence of several public programs which variously tax workers and pay benefits to nonworkers.

A variety of other, smaller projects are underway on topics ranging from unemployment insurance to private pensions. Some have been commissioned on a piecework basis; others are being studied by regular NBER staff members. For example, Sherwin Rosen is studying unemployment insurance and employment-income risk. He is developing a market equilibrium analysis of this problem and will test it empirically next year. Martin Feldstein has been working on basic conceptual issues in analyzing public financing of programs across generations. Lee Lillard is working on short- versus long-term adjustments in labor markets, particularly labor supply, a subject generally neglected in analyses of labor markets but obviously important in understanding how labor markets for the elderly (who, by definition, have a short adjustment horizon) differ from those of the young and middle-aged.

Michael J. Boskin

Economics of Health

Introduction

The research program in the economics of health is supported by grants from the Robert Wood Johnson Foundation, the National Center for Health Services Research (HEW), the Henry J. Kaiser Family Foundation, and the Ford Foundation. Victor Fuchs and Michael Grossman are the co-directors of the program. Daniel Graham, a research fellow from Duke University, and Jerry Green, a visiting scholar from Harvard University, joined the program during the past year.

Michael Grossman, Dov Chernichovsky, Douglas Coate, Ann Colle, Linda Edwards, Jacob Gesthalter, and Fred Goldman are studying economic aspects of children's health. Benefits of improvements in children's health might be substantial. Preliminary and scattered evidence suggests that health at early stages in the life

cycle might be an important determinant of health at later stages and of intelligence, years of formal schooling completed, market wage rates, and hours of work. Given this evidence and the policy goal to improve the health of certain children, it is crucial to provide a theoretical and empirical framework that will promote an efficient allocation of scarce resources by government policymakers. The child health project is attempting to contribute to such a framework. The objectives of the project are to understand (1) the determinants of variations in children's health, (2) the factors that affect the demand for their medical care services and nutrition, and (3) the consequences of variations in children's health with special reference to cognitive development.

Claire Bombardier, M.D.; Victor Fuchs; Daniel Graham; Jerry Green; Lee Lillard; and Kenneth Warner are studying determinants of the cost of medical care and the health of adults. Bombardier, Fuchs, Lillard, and Warner are analyzing socioeconomic factors affecting surgical utilization. Graham is working on theoretical issues involved in the valuation of human life. Green is working on the relationship between health and schooling and on the role of the physician in the demand for medical care.

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

Claire Bombardier and J. Fries. "Variations Among Physicians in the Costs Generated for the Treatment of Rheumatoid Arthritis." Presented at the meeting of the American Rheumatology Association, Chicago, June 1976.

Claire Bombardier, Victor R. Fuchs, Lee A. Lillard, and Kenneth E. Warner. "Socio-Economic Factors Affecting the Utilization of Surgery." Presented at the annual meeting of the American Public Health Association, 1976, and accepted for publication by the New England Journal of Medicine.

Linda N. Edwards and Michael Grossman. "An Economic Analysis of Children's Health and Intellectual Development." Presented at a conference on "The Family and the Subsequent Development of the Child" sponsored by the Mathematical Social Science Board, Stanford, March 1977. Also presented at a Health Economics Research Organization (HERO) session at the Allied Social Science Associations meetings, Atlantic City, September 1976.

Victor R. Fuchs. "Health and Economics." Encyclopaedia Britannica 1976 Annual.

———. "An Economist Looks at Health Care." Hospital Forum, vol. 18, no. 12, March 1976.

———. "A More Effective, Efficient and Equitable System." Western Journal of Medicine, vol. 125, no. 1, July 1976.

Kenneth E. Warner. "Treatment Decision Making in Catastrophic Illness." Medical Care (forthcoming).

———. "The Effects of the Antismoking Campaign on Cigarette Consumption." Presented at the annual meeting of the American Public Health Association, 1976.

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Victor R. Fuchs
Michael Grossman
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Surgical Utilization by Socioeconomic Class

This study measures the relationship between socioeconomic factors and the utilization of in-hospital surgical care in 1970. We also analyze changes in surgical utilization between 1963 and 1970, a period which spans the introduction of Medicare and Medicaid, the spread of poverty health clinics, and other efforts designed to improve access for disadvantaged groups. We examine differentials in surgical utilization and the nature of the differences. If nonwhites or rural residents or low-income families have less surgery than do others, are the differentials fairly uniform by type of surgery, or do they vary by complexity, urgency, or necessity?

The data source is the Health Interview Survey (for 1963 and 1970) conducted by

TABLE 5.1

INDEXES OF COMPLEXITY, URGENCY, AND NECESSITY; ELEVEN SURGICAL PROCEDURES

Operation	Complexity Value[a] (CRVS units)	Rank	Urgency Value[b] (percent)	Rank	Necessity Value[b] (percent)	Rank
Appendectomy	1.12	6	99	1	99	1
Cataract	2.12	3	2	11	96	2.5
Hernia repair	1.00	8	24	5	96	2.5
Prostatectomy	2.21	2	47	4	92	4
Cholecystectomy	1.79	5	48	3	88	5
D&C (excluding abortions)	0.52	10	53	2	77	6
Hemorrhoidectomy	0.71	9	12	7	65	7
Varicose vein stripping	1.06	7	4	10	63	8
Lumbar laminectomy (for disc)	2.88	1	22	6	38	9
Hysterectomy	1.92	4	8	8	28	10
Tonsillectomy	0.45	11	5	9	24	11
Weighted mean values for the eleven procedures (1970)	1.16		28.7		63.9	

Note: Operations are listed by their ranking on the necessity index.
[a] California Relative Value Scale (CRVS) Study (1969) expressed in hernia equivalents (hernia repair = 1).
Derived from questionnaires mailed to California physicians, 93 replies (50 percent response rate).

TABLE 5.2

UTILIZATION RATES FOR ALL SURGERY (EXCLUDING OBSTETRICAL) IN THE UNITED STATES, 1970, BY SOCIOECONOMIC CHARACTERISTICS
(operations per 1,000 population)

	Unstandardized (1)	Standardized for Age, Sex (2)	Standardized for Age, Sex, Race, Residence, Education (3)	Standardized for Age, Sex, Race, Residence, Education, Income (4)
All	55.5	55.5	55.5	55.5
Race				
Whites	57.7*	57.3*	57.4*	56.2
Nonwhites	39.3	42.1	41.8	50.2
Residence				
In SMSA	57.2	57.1*	57.3*	56.9
Out of SMSA	52.3	52.5	52.2	52.9
Education of head (yrs.)				
≤ 8	54.5	50.0†	51.8†	58.3
9–12	57.5	59.1	59.0	58.5
13–14	56.6	58.2	57.0	56.6
15–16	49.4	50.4	48.8	43.7
17 +	50.9	52.3	50.4	36.0
Sex				
Males	51.0*	51.9*	51.8*	51.0*
Females	59.6	58.9	58.9	59.7
Age (yrs.)				
0–9	38.2†	38.4†	38.6†	36.3†
10–19	34.7	34.9	35.0	34.2
20–34	57.1	57.0	56.6	53.6
35–49	71.8	71.8	71.4	67.5
50–64	69.6	69.5	69.4	73.9
65 +	81.2	80.8	81.8	95.5

*Difference significant at .05 level using t test.
†Difference significant at .05 level using F test.

the National Center for Health Statistics. The 1970 interviews were conducted with approximately 37,000 households containing about 116,000 individuals; and the 1963 interviews, with 42,000 households containing 134,000 individuals. We also calculate indexes of "complexity," "urgency," and "necessity" for each of eleven surgical procedures that occur frequently and are well defined. The complexity index is based on the California relative value scale; the urgency and necessity indexes are based on 93 replies (50 percent response rate) by physicians to our mailed questionnaire (see Table 5.1).

The original unit of observation in the survey is the individual person, but in our analysis individuals have been aggregated into cells by year of observation, sex, race (white, nonwhite), residence (inside SMSA, outside SMSA), age (six classes), and education of the head of the household in which the individual resides (five classes). We apply a linear regression model, with cell surgery rates being a function of cell characteristics. Each cell is weighted by the

TABLE 5.3
INDEXES OF TYPE OF SURGERY,[a] UNITED STATES, 1970,
BY SOCIOECONOMIC CHARACTERISTICS

	Complexity Index Standardized for		Urgency Index Standardized for		Necessity Index Standardized for	
	Age, Sex	Age, Sex, Race, Residence, Education, Income	Age, Sex	Age, Sex, Race, Residence, Education, Income	Age, Sex	Age, Sex, Race, Residence, Education, Income
All	100	100	100	100	100	100
Race						
Whites	100	100	101	101	100	100
Nonwhites	99	99	91	87	99	99
Residence						
In SMSA	99	99	97	102	99	100
Out of SMSA	101	101	106	97	102	100
Education of head (yrs.)						
≤8	102†	102†	101	94	103	103
9–12	101	101	98	98	98	99
13–14	95	94	99	103	100	100
15–16	92	90	97	105	98	97
17+	105	109	119	125	104	104
Sex						
Males	104*	104*	102	102	111*	111*
Females	97	97	98	98	89	89
Age (yrs.)						
0–9	56†	58†	48†	43†	63†	62†
10–19	69	68	129	128	90	88
20–34	101	102	130	118	109	105
35–49	128	127	95	98	103	103
50–64	129	126	99	110	124	126
65+	155	159	93	111	137	146

*Difference significant at .05 level using t test.
†Difference significant at .05 level using F test.
[a] Based on eleven selected procedures, see Table 5.1.

square root of the number of persons in the cell. In addition to the dummy variables corresponding to the characteristics used to classify individuals into cells, we also regress on cell family income in several alternative specifications, but we do not group by income.

The results for all surgery (except obstetrical) for 1970 are presented in Table 5.2 in the form of number of operations per thousand population per year. The overall rate is 55.5 per thousand. The unstandardized rate (column 1) is higher for whites, residents of standard metropolitan statistical areas, women, and the aged than for nonwhites, those living outside of standard metropolitan statistical areas, men, and persons under 65. There are also some significant variations in utilization depending upon education of head of family.

Table 5.3 reports the results of regression analyses when the indexes of type of surgery are the dependent variables. In general, we find very little variation in these indexes across the various socioeconomic groups, even when there are significant differences in the surgical rate. It has been speculated that groups that have above-average rates of surgery (or above-average rates of increase in surgery) would have a mix of operations which on average were lower (or which decreased) on the necessity or urgency scales. The data we have examined do not support this view. For instance, the surgical utilization rate of urban nonwhites rose 49 percent between 1963 and 1970, but the average necessity score remained unchanged. Surgical rates for persons 65 and over with eight years of schooling or less also rose substantially, but the average necessity score actually increased slightly during the same period.

In general there was a weakening of the relationship between surgical utilization and family income between 1963 and 1970, as evidenced in Chart 5.1. Additional work on the relationship between surgical utilization and income is being undertaken.

<div style="text-align: right">

Claire Bombardier
Victor R. Fuchs
Lee A. Lillard
Kenneth Warner

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CHART 5.1

PREDICTED SURGICAL UTILIZATION STANDARDIZED FOR AGE AND SEX AS A FUNCTION OF FAMILY INCOME, 1963 AND 1970
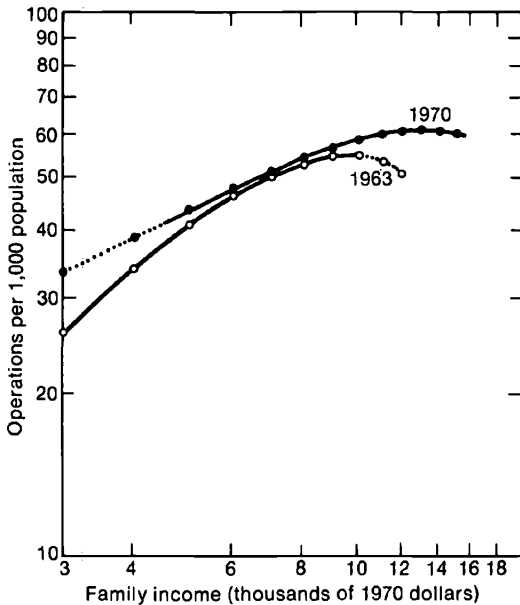
Note: Dashed lines represent predictions outside the 90 percent range of mean cell income in each year.

Doctor and Patient Components in Treatment Cost: Rheumatoid Arthritis

There is growing evidence of wide variation in medical care utilization and expenditures. Previous studies have documented wide variation in medical care costs among doctors. This paper is concerned with the determinants of expenditures for the treatment of the chronic disease rheumatoid arthritis. We consider separately expenditures for medication and expenditures for diagnostic laboratory tests and X rays, as well as the degree of correlation between them. We focus on the contribution of doctor and patient differences to variation in these two aspects of treatment cost.

Data are rarely available for full adjustment for patients' characteristics. Our data provide the opportunity to study the relative

contribution of physicians and patients to the cost of a clinic visit for the treatment of rheumatoid arthritis. In the clinic studied, patients are often seen by different clinic physicians on successive visits. This replication allows the separation of patient and physician components by simple analysis-of-variance techniques. We consider separately the determinants of medication and laboratory costs. The determinants are (1) the physician; (2) measured patients' characteristics, including the medical condition of the patient as routinely measured by the physicians, the distance traveled for treatment by the patient, and the type of insurance coverage; and (3) other important but unmeasured patient characteristics.

The results of this study confirm previous reports of significant variations among doctors in laboratory and medication costs. Year and doctor differences alone explain 10.4 percent of medication cost variation and 2.8 percent of laboratory cost variation, and the net contribution of doctors' differences remains quite significant, even after controlling for patients' measured medical and socioeconomic variables. The most striking result of this study is obtained after we fully adjust for the very significant unmeasured patient differences. The net contribution of doctor differences is reduced to 1.6 percent for medication (MED) costs and becomes insignificant for laboratory (LAB) costs. It appears that most of the variation in cost among doctors is due to the costs attributable to the patients they see. The patient component remained substantial and accounted for 18.6 percent of LAB cost and 28.5 percent of MED cost. A large proportion of the variation in MED cost was accounted for by gold therapy; however it remained significant even after adjusting for gold therapy. The results of this study suggest some caution in interpreting reports of wide variations among doctors' treatment costs where full adjustment for differences in patients is not possible.

Claire Bombardier
Lee A. Lillard

The Choice of Diet by the Household and Its Effect on the Growth of Young Children

Interest in the nutritional status of young American children has heightened considerably in the last decade. Much of the concern has resulted from allegations of undernourishment among young children in low-income families and from recent research suggesting that intellectual development can be permanently·impaired if diets are deficient in the first year or two of life. Interest in child nutrition has not been confined solely to the issue of undernourishment. Recent evidence suggests that overnourishment in the first year of life is an important determinant of adult obesity, perhaps the number one health problem in the United States today. The primary purpose of our research is to analyze the household's choice of diet for its young children (up to 36 months old) and its relation to the children's growth.

As a point of departure, we assume that the utility of household decision makers is positively related to children's growth within the bounds of perceived norms. We hypothesize that nutrient intakes are important inputs in the production of children's growth, although their influence on growth levels is tempered by genetic factors, which are measured or approximated by the height and weight of the mother and sex, race, and birth weight of the child. We further hypothesize that the household demand for the children's nutrient intakes is a function of children's growth, deviations of it from perceived norms, and socioeconomic factors. The endogenous variables in the model are measures of children's growth—height, weight, and head circumference—and nutrient intakes—protein and calories.

The data base we utilize is derived from the Ten State Nutrition Survey, 1968–1970. In this survey dietary and other data were collected by interviews, clinical evaluations, and physical examinations from 24,-000 families residing in low-income areas in the United States. Preliminary results indicate a close association between children's

growth and their diet during their first three years of life. The quality of this diet, however, does not seem to be systematically correlated with household income or mother's education. Hence, the results conflict with the view that low-income households in the United States lack the necessary education or income to provide adequate diets for their children. We do find, however, that protein and caloric intakes are higher in urban areas, in white families, and in small families. Although further study is necessary, these findings do not appear to result from income and education effects. The results also indicate that the allocation of nutrients to children in the household is based on the growth of the children relative to norms. Intakes of nutrients are increased by household decision makers if a child has a low birth weight or is light for his/her age. Similarly, nutrient intakes are decreased if a child is heavy for his/her age. These adjustments are substantial. Low-birth-weight children, for example, have protein and caloric intakes about 20 percent higher than normal-birth-weight children in households with the same socioeconomic characteristics.

Dov Chernichovsky
Douglas Coate

Determinants of Pediatric Care Utilization

The purpose of our research is to understand the determinants of utilization of pediatric care—care rendered to children by all physicians. Appropriate pediatric care is an obvious and natural vehicle for maintaining children's health and an object of government policy via programs such as Medicaid and the neighborhood health center program. Bills introduced in Congress in 1976 by Senator Jacob K. Javits of New York and by Congressman James H. Scheuer of New York would expand the scope of government financing by providing national health insurance coverage for maternal and pediatric care. Our study will shed light on the most effective means of increasing utilization by certain groups of children and will contain estimates of the effects of national health insurance on number of pediatric visits, composition of visits between specialists (mainly pediatricians) and other providers (mainly general practitioners), and the total cost of care.

Our data source will be a 1970 health survey conducted by the National Opinion Research Center (NORC) and the Center for Health Administration Studies of the University of Chicago. It has information on health, medical care utilization, health insurance, and socioeconomic and demographic characteristics of 11,822 adults and children from 3,880 families. In addition, characteristics (age, specialty, board certification status, et cetera) of all physicians in private practice who rendered care to sample families were obtained from the American Medical Association Directory. The NORC sample is a particularly rich source for calculating the "full" price of pediatric care on the basis of family's travel time to and from its usual source of care, waiting time in the physician's office, parents' wage rates, and various parameters of the family's health insurance policy (coinsurance rate, deductible, upper limit, et cetera).

Our work on estimation of demand curves will be guided in part by Linda Edwards and Michael Grossman's study of children's health and intellectual development (see their report below). An interesting implication of their study is a two-regime specification of demand functions for health inputs such as pediatric care. Membership in a given regime is determined by whether or not parents make a financial transfer to their children. The greater the parents' income the greater is the probability that a financial transfer will be made. By dividing our sample into high- and low-income subsamples, we can allow for differences in parameters of demand curves for pediatric care between income classes.

In the context of the two-regime specification, we will focus on estimating parameters associated with variables such as family income, parents' wage rates, parents' schooling, travel time, waiting time, private health

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insurance coverage, Medicaid coverage, number of children in the family, and mother's knowledge of appropriate health practices. Pediatric care will be measured by number of physician visits and alternatively by visits adjusted for the "quality" of the physician. Here the assumption is that the higher average fees of visits to specialists represent a greater quantity of services. Finally, we will examine the determinants of visits to specific kinds of physicians such as board-certified pediatricians.

Ann Colle will devote most of her time to an analysis of the behavior of low-income families. Michael Grossman will focus on the effects of mother's schooling and the extent to which its effects operate via wage rates and knowledge of appropriate health practices. In addition he will estimate child health production functions in the NORC survey.

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Ann D. Colle

Michael Grossman

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An Economic Analysis of Children's Health and Intellectual Development

The basic purpose of our research is to contribute to an understanding of the joint determination of children's cognitive development, which has received a good deal of attention in the literature, and children's health, which has not. As a natural by-product of this overall objective, we explore interrelationships between various aspects of children's physical health and their intellectual development. In particular, we seek concrete empirical evidence concerning the widespread belief that poor health can pose a threat to the cognitive development of children.

During the past year we devoted most of our time to an empirical investigation of the determinants of cognitive development and health of children aged six through eleven. We focused on the roles of home environment variables and proxies for the endowed (initial or inherited) level of health in the current health and development functions so as to uncover similarities in or differences between health and development effects.

The empirical work was guided by an insight provided by a theoretical model of intergenerational transfers of human and nonhuman wealth, as follows: To understand the behavior of parents regarding their children's health and development, it is important to distinguish low-income from high-income families. Clearly, this is a policy-relevant insight, for public policy often is aimed at low-income groups. Our results indicate it would be inappropriate to build policies directed at improving the welfare of children in low-income families on the basis of empirical results derived from an examination of the population at large.

In our general analytical framework we assumed that parents make decisions over two periods or stages in their life cycle. In the initial period their children are completely dependent upon them for financial support, while in the second, the children become financially independent. Parents can affect their children's income or economic well-being as adults in two ways: They can make a financial transfer (a bequest) at the beginning of the period of independence, and they can invest in their children's human capital in the period of dependence. In turn, investments in human capital have two forms: investments in health capital and investments in knowledge or cognitive development capital.

As is usual in models of this kind, we imposed the solvency constraint that parents cannot leave net debts to their children or that the financial transfer cannot be smaller than zero. This implies a two-regime specification of demand functions for children's cognitive development and health. Parents who do not make financial transfers are members of Regime 1, while parents who do make positive financial transfers are members of Regime 2. The higher parents' income, the more likely it is that they are members of Regime 2.

We show that the demand functions in the two regimes have very different properties. In particular, parents' income has a positive effect on health or cognitive development in Regime 1 but no effect in Regime 2. The

marginal cost of investment in human capital enters the demand functions in both regimes. A change in the marginal cost has the same direction of effect in each regime, but the *magnitude* of the effect differs. The marginal cost of investment depends on the prices of inputs such as medical care and parents' time in the production of healthy and intelligent children. It also depends on home environmental variables, such as parents' schooling, that shape the efficiency of the production process and on the children's endowments of health and cognitive development. To summarize, our model has an important implication for the estimation of demand curves for children's health and intellectual development. Besides suggesting the relevant explanatory variables, it calls attention to the necessity of allowing for interactions between parents' income, which is an important determinant of the relevant regime, and determinants of the marginal cost of investment.

Our data source for the estimation of health and development functions is Cycle II of the U.S. Health Examination Survey conducted by the National Center for Health Statistics. Cycle II is a nationally representative sample of 7,119 children aged six to eleven years, examined over the period 1963–1965. This sample is an exceptionally rich source of information about children's health and intellectual development and characteristics of their families. More specifically, the data comprise complete medical and developmental histories of the child, which are provided by the parent; information on family socioeconomic characteristics; birth certificate information; and a school report with data on school performance and classroom behavior, which are provided by teachers or other school officials. Most important, there are objective measures of health derived from detailed physical examinations and scores on psychological (including vocabulary and achievement) tests. The physical examinations and psychological tests were administered by the Public Health Service.

The empirical analysis is restricted to white children who reside with both of their parents. We use three measures of intellectual development and four measures of current health as alternative dependent variables in an ordinary least squares multiple regression analysis. The intellectual development variables are an IQ measure, derived from two subtests from the Wechsler Intelligence Scale for Children, and reading and arithmetic test scores on the Wide Range Achievement Test. The health measures are height, the peridontal index, the number of decayed primary and permanent teeth, and parental assessment of the child's current state of health. Height is a standard indicator of children's nutritional status, and good nutrition is an obvious and natural vehicle for maintaining children's health. The peridontal index and the number of decayed teeth are measures of oral health and also reflect nutritional status. Parental assessment of the child's current health is employed as a dependent variable to show how results differ when health is measured subjectively by parents as opposed to objectively by physicians. To estimate the two-regime model, we divide the sample into two income subsamples: children whose families have an annual income under $7,000 and those whose family income is $7,000 or more.

Our major findings are:

1. The prediction of two distinct regimes or two different relationships between each of our health and development variables and the set of explanatory variables is generally supported by our results. Statistically significant differences in the sets of coefficients for the two income classes are reported for five of seven dependent variables. Although these results cannot be characterized as "unanimous" support for the basic structure of our model, they do constitute stronger verification than may be initially apparent. The two income classes used here are unlikely to coincide completely with the two regimes specified by the model. The resulting misclassification of observations will tend to bias the coefficient in the two income classes toward equality, making it more difficult to obtain significantly different coefficients in the two

income classes even though such differences do exist in the two regimes. We observe significant differences in coefficients for five of our seven variables despite this bias toward finding no such difference.

2. The prediction that income will have a positive effect on health or development for families in Regime 1 and no effect in Regime 2 receives weaker support in our results. For the two achievement measures, income has a positive, significant impact for lower income families and a nonsignificant impact for upper income families. For the other dependent variables, family income is either statistically significant in both income classes or in neither class. One likely explanation for the significant coefficients in the upper income class is the previously mentioned bias resulting from the misclassification of observations. In particular, it is likely that members of Regime 1 are erroneously included in the over-$7,000 income class, causing an upward bias in the coefficient of income for that class.

3. When height is the measure of health, parents' schooling, mother's work status, and family size are significant predictor variables in the low-income sample but not in the high-income one. On the other hand, these three variables tend to be as important (or more important) predictors of intellectual development in the high-income sample as in the low one.

4. Health endowment and investment measures have significant, positive effects on cognitive development. In particular, cognitive development scores are higher when children weighed more than five pounds at birth, when they were breast-fed, when their current hearing is normal, and when abnormal vision is corrected by the use of eyeglasses. These findings suggest that prenatal and pediatric care programs that could identify high-risk mothers and children at modest cost would have relatively high expected benefits.

Our findings highlight at least two fruitful areas for research in the coming year. One is an investigation of the extent to which endogenous current health measures affect intellectual development. The second is an investigation of health and development relationships at later stages in the child's life cycle. Both of these will contribute further to our understanding of how health and development interact and will provide more refined measures of benefits from investments in children's health.

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Linda N. Edwards
Michael Grossman

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Effects of Mother's Schooling on Children's Health

The aims of this research are to examine the role of mother's schooling in the production of children's health and in the demand for health inputs such as curative pediatric care visits, preventive pediatric care visits, and parents' time. Health production functions and input demand functions will be estimated in a special sample of New York City residents conducted by the New York City Department of Health (the Mindlin-Densen Survey). This is a longitudinal and cross-sectional survey of infants and preschool children, covering twenty-one months of the period 1965–1966. It contains a variety of health indexes, including mother's evaluation of children's health, number and type of acute and chronic conditions, and number of restricted-activity days due to illness (total and per condition). These measures and health inputs are available monthly or bimonthly over a one-year period. Therefore, the effects of pediatric care and other variables on child health outcomes can be traced, with proxies for initial state of health or seriousness of illness held constant.

Typically, the mother is the main provider of child health care in the family. Consequently, differences in her schooling might affect the overall efficiency of the production process (the amount of output obtained from a given set of medical care and time inputs) as well as the relative productivity of various inputs. By estimating production functions for various conditions, we allow the effects of mother's schooling to differ by type of condition. In this context two plausible hypotheses are that the schooling effect and the interaction between schooling

and pediatric care are larger for those conditions in which health care makes a difference in health outcomes.

If schooling affects absolute and relative productivities of inputs, it can alter the composition of inputs by means of income and substitution effects. Estimates of demand functions for preventive pediatric visits, curative pediatric visits, and the mother's own time input will quantify the partial effects of mother's schooling in the input demand functions. In addition, these estimates will enable us to explore the hypothesis that an increase in the relative productivity of an input because of schooling will increase the quantity demanded of that input.

Gesthalter is devoting most of his time to the above research. Goldman is studying trade-offs between public and private pediatric care in the production and demand for children's health.

Jacob Gesthalter
Fred Goldman

Willingness to Pay

This research aims at clarifying certain conceptual problems associated with using "willingness to pay" measures in evaluating public-sector projects. The analytical foundation of this valuation method—the "compensating variation" of Hicks and the "hypothetical compensation" test of Kaldor, Hicks, and Scitovsky—is built upon a timeless and certain world with complete markets. There are significant difficulties, both positive and normative, in extending this analytical basis to the temporal and uncertain world in which projects must typically be evaluated.

The positive difficulties can perhaps best be described by first summarizing "willingness to pay" in a static, certain world of apples, oranges, and public parks. Here there are a variety of combinations of apples and oranges that an individual would willingly sacrifice for an additional unit of parks. The outer boundary of this "willingness-to-sacrifice" set would appear (under conventional assumptions) as a smooth curve, strictly concave to the origin in a two-dimensional graph with payments in oranges and

payments in apples plotted along the axes The existence of markets for apples and oranges in which the individual is a price-taker transforms this willingness-to-sacrifice curve into a line whose slope reflects the relative price of apples and oranges and which is tangent to the willingness-to-sacrifice curve. Along this line all combinations of apples and oranges have the same market value, and this market value is identified as "willingness-to-pay." What is important here is the realization that it is the existence of markets for all other goods that provides the "common denominator" by which the multidimensional willingness-to-sacrifice curve is transformed into the scalar magnitude willingness-to-pay.

Consider now a simple illustration from a temporal and uncertain world. At issue is the appropriate value to attach to airbags, a passive restraint system for automobiles. Here the potential user suffers from uncertainty regarding which of two possible events will occur: wreck or no wreck. Making use of the notion of contingent commodities we may again consider a two-dimensional willingness-to-sacrifice curve in a coordinate system with payments in "dollars, if wreck occurs" plotted along one axis and payments in "dollars, if no wreck occurs" plotted along the other. If markets exist in which financial claims against these contingencies can be bought and sold at given prices, this willingness-to-sacrifice curve would again be transformed into a line along which market value is constant and a scalar magnitude representing willingness to pay would again emerge.

The problem, of course, is that unlike markets for sure deliveries of apples and oranges, these contingent claims markets typically do not exist. One obvious reason for their absence is the tremendous number of such markets required for complete coverage. If, for example, there were six people in a society and each could find himself in one of ten "individual states" (alive, dead of heart attack, dead of automobile wreck, etc.) then there would be 10^6 social states of the form: all six survive; 1 survives and 2 through 6 die of heart attack,

etc. In short, 1 million contingent claims markets would be required for complete coverage. Under restrictive circumstances (all individuals alike in endowments, tastes, and probabilities with independent risks) the required number of markets would collapse to ten—a market for annuities plus nine insurance markets, one for each cause of death. Even in these restrictive circumstances one market for life insurance is not sufficient for complete coverage because it requires that the buyer purchase identical amounts of nine inherently different types of insurance.

In the absence of complete markets, what magnitude should be identified as willingness-to-pay? The one most frequently employed is that associated with requiring the same payment in all states. In the airbag example, the intersection of the forty-five-degree line with the willingness-to-sacrifice curve, yields this maximum "sure payment." Another measure frequently mentioned is "expected consumer surplus," the expected values of willingness to pay if "wreck" were certain and if "no wreck" were certain. (This combination of payments is also on the willingness-to-sacrifice curve.) In partially completed research, the relationship between these two magnitudes is clarified, and a third measure, "expected willingness to pay," is suggested as the conceptually correct measure of value for many public policy decisions. In this approach, that combination of payments along the willingness-to-sacrifice curve is selected which has the greatest expected value. Here an airbag buyer would contract for one payment if "wreck," and another, possibly different payment, if "no wreck." A seller entering into a sufficiently large number of these contracts (assuming independent risks) would collect the sum of these expected values with virtual certainty (with an arbitrarily small variance), and no alternative payments mechanism could increase these receipts. By virtue of this payments mechanism, the seller becomes a joint provider of airbags and wreck insurance.

In this context, useful insights were gained regarding the value of reductions in the probability of loss of life or other goods for which there are no perfect market substitutes. New perspectives were gained on issues ranging from an individual's willingness to buckle his seat belt to his willingness to pay for flight insurance. Similarly, the correct "option value" could be identified of preserving irreplaceable natural resources such as the Hell's Canyon region of the Snake River. Finally, the extent to which observable behavior in existing contingent claims markets yields information pertinent to valuing the good whose loss characterizes the contingency was examined.

In separate but related research, I have investigated the normative aspects of willingness-to-pay in a temporal or an uncertain context or both. The difficulties here came about because one person becomes a multiplicity of recognizable interests. Willingness to pay based upon today's preferences may or may not be compatible with calculations based upon tomorrow's preferences. Similarly, if bets are placed in contingent claims markets it is possible to be a loser in particular states. Hence, I examined the extent to which current willingness to pay could be justified in terms of hypothetical compensation.

Daniel Graham

6. INTERNATIONAL STUDIES

Introduction

The international program has continued to grow during the past year, with several new studies begun and plans made for additional projects to start in the coming year. The Bureau's international activity includes, aside from research, an international exchange of scholars, a fellowship program, and a conference series; the last is described below in this section by M. Ishaq Nadiri; the report on fellowship programs, by Douglas H. Eldridge, is in section 9. Both the research and the other international activities have involved the participation of economists from many countries and cooperation with foreign research institutions.

Among the studies begun during the year was the one by Schwartz, Darby, Klein, and Lothian on the international transmission of inflation through the world monetary system. That study together with Cagan's research on the effect of world commodity prices on U.S. manufacturing prices and the Kravis-Lipsey study of foreign inflation and exchange-rate influences on several countries' export and domestic prices represent a wide range of approaches, using completely different data, to the analysis of the transmission of price impulses from one country to another.

The continued expansion of the Bureau's involvement with economic problems of less developed countries was reflected in several projects. These include Narongchai Akrasanee's new study of trade policies of Thailand; the initiation of work on a model of trade and development in the Pacific basin, by Bert Hickman and Lawrence Lau; the continuation of Anne Krueger's major collaborative project on alternative trade strategies and employment; and the Latin American workshop series. The most recently planned of these workshops, to be held in the coming year, will deal with commodity markets, models, and policies in Latin America. Another notable activity was the conference of the Universities–National

Bureau Committee on Population Growth and Economic Change in Less Developed Countries. One of the projects planned for the coming year, the study by Kravis, Lipsey, and Nadiri on the indexing of commodity prices, also addresses a question that has been of particular concern to less developed countries in the last few years.

Some other new and proposed projects in the area of multinational firms and the progress of the U.S.–U.S.S.R. Scientific and Technical Program of Cooperation, directed by McMains, Meyer, and Smith, are described in the separate reports below.

Publication of volumes on Colombia, by Carlos Díaz-Alejandro, and on Chile, by Jere Behrman, completed the country studies in the Bhagwati-Krueger project, *Foreign Trade Regimes and Economic Development.* Anne Krueger's synthesis volume has been approved by the Bureau's Board of Directors and completion of the companion volume by Jagdish Bhagwati is expected very shortly. Also among the international publications for the current year are *Money, Financial Flows, and Credit in the Soviet Union,* by George Garvy, and a collection of papers from the Conference on Indexation, edited by M. Ishaq Nadiri and Affonso C. Pastore, in volume 4, number 1 of *Explorations in Economic Research.*

Robert E. Lipsey

The International Transmission of Inflation through the World Monetary System

We have begun research focusing on the role of the world monetary system in the international transmission of inflation. The principal thrust of the study will be the development and estimation of a unified quarterly model to investigate major issues in both the short-run transmission process and the long-run equilibrium and stability of the system. The model will comprise three elements: (1) reaction functions explaining

government monetary, fiscal, and exchange rate policy as responsive to national and international economic conditions; (2) national macroeconomic equations explaining the behavior of key national macroeconomic variables of concern to policymakers, namely, nominal income, real income, the price level, and unemployment; (3) equations explaining balances of payments and exchange rates as simultaneously determined and describing the nature of the forces that produce differences among countries in their rates of inflation.

At this stage of the study, only the second of the three elements has been specified—the part of the model designed to explain movements over the period 1955–1976 in output and the price level of individual countries in our sample (the United States, Canada, Japan, Germany, the Netherlands, France, Italy, the United Kingdom). The movement of the economy in the model is viewed as reflecting two types of forces. The first are macroeconomic shocks which either change the moving equilibrium of the economy or move the economy away from an unchanged equilibrium; the second, equilibrating forces which move the economy toward equilibrium, though not necessarily smoothly or rapidly, when the economy is away from equilibrium. The monetarist-Keynesian debate has been largely due to differences of opinion as to the variances and impacts of different types of shocks and to the rapidity of the adjustment toward equilibrium. The model has been formulated so as to allow the data (rather than assumptions) to answer these empirical questions.

In the model, two behavioral equations and an identity will determine nominal income, real income, and the price level. On the basis of work to date, it appears that the behavioral equations are best formulated as a nominal income equation and a real income equation with the price level determined by the identity. This approach permits relatively simple implicit modeling of complex price adjustment behavior not permitted by the standard price level equations but required for long-run equilibrium.

For example, lags in the adjustment of the price level in early stages of increased money growth imply that at a later period rates of inflation will increase temporarily by more than the increase in the growth rate of the money supply in order to restore equilibrium. This catch-up in the price level is readily implied by the adjustment of real and nominal income toward their respective equilibrium values. An explicit price equation incorporating the somewhat different shocks affecting nominal and real income appears awkward.

The nominal income equation will combine a tendency toward equilibrium of money supply and money demand with measures of monetary, fiscal, and international stimulus. The real income equation will combine the tendency toward a natural-employment real income with the short-run effects of unexpected changes in nominal income and of domestic and international supply shocks.

Expected values are important variables in our model. The basic theoretical approach underlying the model can be viewed as combining elements of the monetarist, rational expectations, and neoclassical growth literature. The rational expectations approach divides changes in variables into those which could be rationally predicted by extracting the information in the past values of the variable and related series and the residual or unexpected changes. Much emphasis has been placed on the proposition that expected changes in money will be reflected in price changes while unexpected changes affect real income and employment. Similar distinctions between the effects of expected and unexpected changes in such other variables as government spending and exchange rates can be fruitfully made.

We initially indicated that we would construct expected values for the money supply or high-powered money by estimating central bank reaction functions. We have since deferred the estimation of the reaction functions until the data base is substantially complete, and in the meantime we shall use estimates of expected magnitudes derived

from the Box-Jenkins ARIMA technique that extracts all the information in the past history of a series. At a later point we shall compare these estimates with those derived from central bank reaction functions and other government reaction functions. It is a convenience to use Box-Jenkins estimates at this juncture in the trial runs of the model, although the estimates will be of interest in themselves in comparing them with reaction function results.

The central banks' reaction functions will indicate the response of monetary authorities to economic developments in the domestic and international spheres in manipulating domestic credit relative to foreign reserves. The response will figure in the transmission mechanism, not merely in the derivation of expected values for money or high-powered money. Since during most of our period the international monetary system consisted of a dominant-dollar pegged exchange rate, one variable we shall test in reaction functions for money supply in countries other than the United States is changes in central bank holdings of official reserves. This should enable us to test the hypothesis that the United States exported inflation to the rest of the world during the 1960s. We should also be able to test if the balance of payments served at all as a constraint on U.S. monetary policy, or whether the United States acted as an independent dominant money supplier.

We may also find it useful to break up the time period when estimating reaction functions if we can determine that a significant change occurred in U.S. and foreign central bank behavior over time. In addition, it will be instructive to use changes in purchasing power parity as an alternative measure of foreign influence on domestic monetary policy, since changes in official reserves may not represent a disequilibrium phenomenon but merely an increased demand by the foreign central bank for reserve holdings.

Another possible international transmission mechanism we plan to investigate concerns substitution between monies on the demand side of the market. There may be competition between alternative money supply issuers in the international money market. This would imply that even under a system of flexible exchange rates, an individual country will not be completely insulated from money supply changes abroad, since such foreign changes could influence the demand for the country's money through international substitution (e.g., if individuals in England increased their demand for marks and reduced their demand for pounds in reaction to a U.K. inflation). An initial crude test would entail including foreign interest rates in each money demand equation. Since limited degrees of freedom are available, it may be difficult to carry out this test.

We have not yet begun the modeling of the international transmission element of the full model, and that will be our major task during the next few months of our work. After we estimate our complete model we intend to compare the differential reaction of real income and prices to monetary shocks among the different countries to see if the fraction of the shock that affects real magnitudes (the coefficients on the effects of unexpected changes in the real income equation) is positively related to price uncertainty over the last two decades. A useful starting point for such a measure of average price uncertainty would be the standard error of estimate of an ARIMA process on the rate of inflation for each country.

The statistical estimation of the unified model presents the formidable data requirements of a postwar quarterly data base for each of the eight major countries studied. International data are uneven in availability, consistency, and accuracy.

Anna J. Schwartz
Michael R. Darby
Benjamin Klein
James R. Lothian

The Effect of World Commodity Prices on U.S. Manufacturing Prices

This study, which is part of a broader examination of short-term price determination and particularly of the relation of output prices to input prices, is focused on the distinction between inputs for which prices are determined in international markets and those for which prices are affected mainly by U.S. developments. It asks how much of output price change can be attributed to prices of traded inputs and whether the response of output prices to prices of traded inputs differs from the response to prices of domestic inputs.

Price indexes were constructed for outputs and inputs in 54 U.S. manufacturing industries covering 79 percent of the manufacturing sector. A matching of input and output price indexes had not been available for detailed industries before. The input price indexes were divided into world-traded and domestic products, with the former defined by the fraction of domestic supply imported and exported. The series so far compiled run from 1968 to May 1975. The price indexes are supplemented by series for each industry on straight-time average hourly earnings of production workers.

The first step in the analysis was to estimate the time pattern of effects of input prices on output prices. These estimates were derived from regressions of quarterly changes in output prices on changes in input prices and earnings. It was assumed that changes in materials costs and wages were passed through to output prices over the period of a year and that demand conditions did not appreciably affect the pattern of the pass through. Lag patterns of input price effects covering the concurrent and two lagged quarters were estimated for each industry. There is no indication that domestic and world-traded inputs had different lag patterns.

The second step was to trace price changes of world-traded goods through the manufacturing sector from one industry to the next. Feedback of output prices in selling industries on the input prices in purchasing industries was taken into account in this analysis, but not feedback on wages. For example, prices of grains and soybeans rose 110 percent from third-quarter 1972 to third-quarter 1973. Together they account for 17.5 percent of the materials inputs to the processed foods sector. The effect on an average of all 54 industries weighted by gross outputs was to raise the average output price 2.2 percent by third-quarter 1973 and 3.2 percent by second-quarter 1974. The actual increase in the average over this entire period was 26.3 percent. We can therefore state that these inputs accounted for (3.2/26.3 =) 12 percent of the increase in manufacturing prices. Such calculations will be carried out for all world-traded goods.

Phillip Cagan

Price-Quantity Relations in U.S. Trade

This project is part of a series growing out of our earlier work on international price measurement and the analysis of responses to price changes. Much of the work during the past year has been on differences between export and domestic price movements, the role of export prices in the transmission of inflation, and the relationship between prices and exchange rates.

Several papers have been completed or published during the year. "Export Prices and the Transmission of Inflation" was published in the *American Economic Review,* Papers and Proceedings, February 1977. The results reported there indicated that commodity markets for manufactured goods are sufficiently tied together that a rise in an important country's domestic prices is reflected in other country's prices. However, the adjustment is often incomplete, is delayed a year or so, and is faster and larger for the affected country's export prices than for its domestic prices. There is thus a flexibility in the links between na-

tional price systems that is not always taken into account.

Three working papers have also been drafted: "Export and Domestic Prices Under Inflation and Exchange Rate Movements" (NBER Working Paper 176), "Price Behavior in the Light of Balance of Payments Theories" (NBER Working Paper 181), and "Export Prices and Exchange Rates," with Eliot R. J. Kalter (NBER Working Paper 182). The first is an expanded version of the *AER* paper, and is a study of the response of export and domestic prices in three countries—the United States, Germany, and Japan—to foreign prices and exchange rates. The second, a comparison of price movements with those that would be expected under various theories of balance of payments adjustment, was presented at a conference on Purchasing Power Parity in Athens, Greece, and will be published in the *Journal of International Economics,* May 1978. The third is a study of the pass-through of exchange rate changes to U.S. export prices.

The price data available for these studies, extending through 1974 or 1975, now include U.S., U.K., German, and Japanese domestic price indexes and German and Japanese export price indexes for all manufactured goods. In addition, there are U.S. export price indexes for machinery and transport equipment.

Further work is under way, using our international price competitiveness indexes for machinery and transport equipment to explain changes in the volume of exports. We are extending some of our earlier analyses through 1975 to cover the period of more flexible exchange rates and are also examining exports to particular destinations and for more detailed commodity groups than in earlier studies.

The financing for this research was originally provided by the National Science Foundation and has been supplemented by the Office of Competitive Assessment of the U.S. Department of Commerce and by the U.S. Department of State. Mary Boger, Marianne Rey, and Judy Rosenzweig were responsible for data collection and programming during the past year.

Irving B. Kravis
Robert E. Lipsey

Studies of Multinational Firms

The program of research on multinational firms is a set of related studies, most of which make use of the National Bureau's data base on U.S. firms and the reports on U.S. companies and their foreign affiliates collected by the Bureau of Economic Analysis of the U.S. Department of Commerce.

The study of the impact of multinational firms on technology and trade flows was completed during the year with a final revision of the paper by Arthur Lake, "Foreign Competition and the U.K. Pharmaceutical Industry" (NBER Working Paper 155, November 1976). Plans are now being made for a follow-up study which will concentrate on some of the less technologically advanced industries, in contrast to the pharmaceutical and semiconductor industries which were the subjects of special studies in the first project. Transfers of technology in the form of production methods or new products and the effects of such transfers on trade flows would again be the focus of the research, but with greater attention to U.S. imports than in the earlier work. We also plan to carry out some studies of the operations of U.S. firms in several countries or areas, comparing them to local firms with respect to size, factor proportions, efficiency, and other characteristics, and investigating the impact of the activity of U.S. firms on locally owned companies.

Some exploratory work was done during the year on a study of the factors determining the location of manufacturing operations, and particularly manufacturing for export, by U.S. companies. We have been trying to develop appropriate models of overseas activities of U.S. firms and also data on costs of labor in different countries, adjusted for the wide variation in education and other elements of labor quality. We also

have been experimenting with measures of the costs of fixed capital, making use of the capital equipment and construction prices developed in the United Nations project on real income comparisons. We hope to complete a preliminary working paper on this topic shortly and are seeking support for further research.

A new project on the relation between domestic and overseas capital investment by individual U.S. firms, in which Guy Stevens of the Federal Reserve Board will be cooperating with Robert Lipsey, is just getting under way. The first step in the study is the assembling of some unusual data which will include, for over a hundred individual firms, information on sales, sales forecasts, investment plans, actual investment, and other variables, divided between activities in the United States and activities overseas. The study will try to assess the extent, if any, to which investment overseas is a substitute for investment in the United States by the same firm or, possibly, its competitors.

Another current study, part of the project on alternative trade strategies and employment, is concerned with factor use by U.S. multinational firms in less developed countries. We find, in virtually all industry groups, higher capital-labor ratios in U.S. parent companies than in their affiliates in developed countries and higher ratios in those affiliates than in the ones in less developed countries. We are trying to learn how much of this difference is explained by industry mix within industry groups, how much by the use of different technologies, and how much by adaptation within given technologies. We are hoping to use for this purpose, in addition to the U.S. data, similar information on the foreign operations of Swedish firms, collected by the Industriens Utredningsinstitut. Another subject of study is the differences in factor proportions between U.S. affiliates and other firms in host countries. Romualdo Roldan of the University of Pennsylvania is working with us on this topic.

The National Bureau's studies of multinational firms were begun under grants from the National Science Foundation and the Ford Foundation, and the more recent work has received financing from the Agency for International Development, the U.S. Department of Labor, and the Treasury Department, as well as assistance in kind from the Federal Reserve Board. In many of these studies we are 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 and advice in using the data.

Irving B. Kravis
Robert E. Lipsey

Alternative Trade Strategies and Employment

The past year has been devoted to gathering and analyzing data for individual country studies. In late August, all project participants assembled for a second working meeting in which preliminary findings were presented and research strategies discussed. It is expected that all data will have been gathered by the time this report is published. There are already first drafts of some country studies, and it is hoped that all country studies will be completed by the summer of 1977.

Among the preliminary findings of interest, perhaps the most striking is the uniformity with which country authors are finding that exports to other LDC's are far more capital using and less labor using than their exports to developed countries. In a number of studies skill intensity has been found to be even more significant than capital intensity in distinguishing between export and import-competing industries, but those results are less uniform across countries and require further analysis.

Anne O. Krueger

Selected Issues in Trade Policies of Thailand and Trade Strategies for Employment Growth

Since the beginning of my fellowship, in July 1976, I have been engaged in two

major areas of research. One is selected issues in trade policies of Thailand and the other is trade strategy for employment growth. Two issues of trade policy were selected: rice export policy and cooperation in trade policies with ASEAN countries. The study on trade and employment follows the outline of the NBER project of the same title.

The study on rice export policy has produced three papers, which will be published in the forthcoming Stanford Food Research Institute Studies, Volume 25, Number 2: "Comparative Advantage in Rice Production: A Methodological Introduction" (written with Scott R. Pearson and Gerald Nelson), "Comparative Advantage in Rice Production in Thailand" (written with Atchana Wattananukit), and "Comparative Advantage in Four Rice Producing Countries" (written with Eric Monke and Scott R. Pearson).

The first paper contains a discussion of the concepts and methodology to be used for policy analysis of a commodity such as rice. These include private and social profitability, nominal and effective protection, and domestic resource cost. In the second paper, these concepts were used to assess the rice export policy of Thailand. It was found that Thailand had a very strong comparative advantage in rice export, as indicated by social profitability and domestic resource cost. Yet the results from nominal and effective protective rates showed very clearly that government policy discouraged rice export. In the third paper, the results for Thailand were compared with those for the United States, Taiwan, and the Philippines. Among the four countries, Thailand demonstrated the strongest comparative advantage and the Philippines the least. The results were used to analyze the rice policies of these countries.

The study on ASEAN produced one paper entitled "Development of Trade Policies in Thailand and Prospects for Trade Cooperation with ASEAN," which will be published by the United Nations Asian Development Institute in Bangkok. The paper outlines the development of trade policies from the end of the Second World War up to 1976. It points out that the policies have been quite liberal, with attempts at import substitution in the 1960s and export expansion from the early 1970s up to the present. At the next phase of import substitution, economy-of-scale considerations call for a larger market, and this could be accomplished through cooperation with ASEAN countries. Cooperation is thought to be viable because of some complementarity of Thai export products with ASEAN countries.

The project on trade strategies for employment growth has been divided into four parts: analysis of trade policy, factor proportions of trade, distortions in factor prices and factor markets, and trade and employment. I had written a paper on the first part before coming to the National Bureau. The paper was revised during my stay at the Bureau, and this version will be published in the Papers and Proceedings of the Eighth Pacific Trade and Development Conference, to be distributed by the University of Hawaii Press in mid-1977. In the paper I present results on nominal and effective protection as indicators of trade policies, and analyze employment implications of these policies. I conclude that policies in the early 1970s encouraged the substitution of capital for labor.

Second drafts of papers on the second and third parts have been written. The first paper is a report on factor proportions in trade. Import-competing industries were found to be more capital intensive than export industries, both in 1971 and 1973. Factor intensities were also consistent with the factor proportion theorem in terms of the direction of trade. Finally, it is noted that factor-intensity differentials were very large.

The second paper is on wage differentials in the manufacturing sector. It is shown that there were substantial wage differentials in the sector and that the most important explanatory factors were the male-female ratio and size of the firm. The tentative conclusion is that wage distortions and differentials exist in the Thai manufacturing sector.

Research results described above were presented at seminars at various

universities and institutions. Results in relation to the trade and employment project were presented at the University of Minnesota, Yale University, the Agency for International Development, the World Bank, and the University of Hawaii. The paper on ASEAN was presented at Harvard University, Simmons College, and the Asia Society in New York. The rice export policy paper was presented at Boston University, the University of Minnesota, and the National Bureau in New York.

I am currently completing my research on trade and employment. I am revising the work on factor proportions and factor price distortions and analyzing the implications of trade policies on employment.

Narongchai Akrasanee

A Model of Trade and Development in the Pacific Basin

The purpose of this project, which began July 1, 1976, is to study the interdependencies between developed and developing economies in the Pacific Basin and to assess the effects of introducing new systems or rules for international economic transactions in that region. The Pacific Basin regional economy includes all the national economies that border on the Pacific Ocean, except the Latin American economies. The latter are excluded on the grounds that their trade and investment ties are primarily with the United States or Europe and almost negligible with the rest of the Pacific Basin. The Pacific Basin regional economy has been one of the fastest growing regions in the world in terms of international trade and foreign investment.

The project will be concerned with economic policy issues which have international implications, such as the impact of growth recessions in the developed economies, changes in export and import prices due to proposed preferential tariff schemes and to the formation of an ASEAN customs union, and exogenous changes in foreign aid or net capital flows.

The approach is based on building and operating an econometric model of interdependencies among the developed and developing economies in the Pacific Basin. Individual national models for the various countries will be linked through a central model of the trading relationships among the Pacific Basin countries and between them and other regions of the world. The complete system will be used to analyze the problems of international transmission of economic disturbances and the organization of alternate trade systems.

The countries and regions that will be individually distinguished are Australia, Canada, the Republic of China, the People's Republic of China, Hong Kong, Indonesia, Japan, the Republic of Korea, Malaysia, New Zealand, the Philippines, Singapore, Thailand, the United States, the U.S.S.R., Western Europe, oil-producing countries of the Middle East, other Middle Eastern countries, oil-producing countries of Africa, other African countries, oil-producing countries of the Western Hemisphere, other Western Hemisphere countries, Socialist countries of Asia, other Asian countries, Socialist countries of the rest of the world, and rest of Oceania.

The goals for the initial year include the development of the basic trade and national income data files and the construction of the trade model. The basic trade data file is now complete. Trade matrices representing the flows of trade within the Pacific Basin and between it and the other regions have been assembled for each year from 1948 through 1975. From these trade matrices, complete bilateral trade balance matrices have also been constructed, giving the trade surplus (or deficit) of any one country or region with any other. Trade share matrices based on import and export shares have also been constructed for each year to reveal the changes in the structure of imports by origin and exports by destination of each country and region over time. Work has also been started on the compilation of capital flow matrices for the Pacific Basin for selected recent years.

In parallel with the trade-modeling effort, a complete national income accounts data file will be set up for each of the countries

and regions included in the study. This data file will be used in the construction of individual-country econometric models. Work is underway on the specifications of a prototype national model incorporating the relevant features for the proposed regional system.

Bert G. Hickman
Lawrence J. Lau

Latin American Computer Workshops

During October 1976 we had planned to hold a large conference on commodity markets, models, and policies in Latin America, sponsored jointly by the National Bureau, the Coffee Federation, and the Banco de la República of Colombia, in Bogotá, Colombia. However, the conference was postponed at the request of the Banco de la República and the Coffee Federation.

The discussion was to be organized around the following subjects: (1) primary commodity exports of Latin America: interrelationship with international and domestic markets; what can Latin America do in international commodity planning?; (2) long-term projections: forecasting the metal markets for today's investment decision; the world sugar economy—an econometric analysis of production and policies; programming approach to intercrop planning; transnational commodity policies and national interests; (3) international commodity stabilization: compensatory finance mechanisms; and (4) Latin America: an agenda for action in research and policy implementation.

Two other conferences have been tentatively scheduled for 1977. One, jointly sponsored with ECIEL (Programa de Estudios Conjuntos sobre Integración Económica Latinoamericana), is on education and economic development in Latin America. The other planned workshop will deal with economic aspects of the role of government in the Latin American economies. It will be jointly sponsored with CIEPLAN (Corporación de Investigaciones Económicas para Latinoamerica).

A series of articles presented at our conference on indexation in São Paulo, Brazil, February 26–28, 1975, was published in *Explorations in Economic Research,* volume 4, number 1. Papers given at the conference on planning and short-term macroeconomic policy in Latin America, in Isla Contadora, Panama, October 31–November 2, 1975, are also scheduled to be published.

These workshops were made possible by a grant from the IBM World Trade Corporation.

M. Ishaq Nadiri

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

During 1976 the National Bureau of Economic Research continued to plan and coordinate a program of cooperation in econometric modeling (Topic 1) and modeling of large-scale systems (Topic 2) under the U.S.-U.S.S.R. Scientific and Technical Program of Cooperation in the Field of Application of Computers to Management. There are presently five topics in the area of application of computers to management which have the approval of the joint U.S.-U.S.S.R. commission appointed to monitor and authorize these activities by the U.S. and Soviet governments. The chairman of the U.S. side of this area of cooperation is Donald Aufenkamp of the National Science Foundation.

The Bureau has been involved in the program for the last three years but will end its participation sometime in 1977, and is presently arranging to transfer these activities to such other institutions in the United States as may be designated by the National Science Foundation.

Progress was made during the year in development of joint longer-term work on selected research topics by scholars of the United States and the U.S.S.R. The first of these longer-term exchanges took place in May 1977, with Alfred Dale (University of Texas-Austin) and Edward Sibley (University of Maryland) working in the U.S.S.R. for one month on data structure

models (Topic 1). This activity was planned and contemplated in the protocols signed over the past three years. Additional long-term visits for subtopics under Topic 2 are expected to take place later in 1977. The first one contemplated is a visit by Donald Aufenkamp (NSF) to the U.S.S.R. for two months for research on information flows in complex systems. A return visit to the United States by Soviet experts on computer information systems is planned for late fall.

During the year the following technical seminars were held:

U.S.S.R.:

Econometric Modeling of Various Aspects of the Economy—Moscow

Computers Applied to Planning and Management of Large Agro-Industrial Complexes—Moscow, Riga, and Kishinev

United States:

Management Information Systems—Denver

Data Base Management—Austin

Enterprise and Decision Models—Washington, D.C.

In addition, Alfred Dale (University of Texas), Judy Thornton (University of Washington), Holland Hunter (Swarthmore),

Robert Leone (Harvard University), and David Kresge (NBER) visited the Soviet Union during 1976 to discuss longer-term research exchanges between U.S. and U.S.S.R. scholars in the areas of transportation, energy, enterprise, and decision models, as well as data base management.

Plans for publishing the proceedings of the Econometric Modeling, Transportation, Management Information Systems, and Agricultural seminars are complete and these publications will be available sometime in the latter part of 1977.

During the year the Bureau's collection of U.S.S.R. publications obtained over our three years of involvement in this program was transferred to the University of Chicago as requested by the National Science Foundation. This material will be maintained as part of their larger collection of specialized Soviet publications on mathematics and computer-related sciences. These publications will be translated and made available to interested scholars through a program funded by the National Science Foundation.

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

7. THE NBER URBAN SIMULATION MODEL AND EVALUATION OF THE MARKET EFFECTS OF HOUSING ALLOWANCES

Completion of a three-volume final report during the past year fulfilled NBER's obligations to the Department of Housing and Urban Development under its 1972 contract with HUD to "improve the NBER urban simulation model and to analyze housing market dynamics and abandonment." The NBER Urban Simulation Modeling project, which received initial support from HUD in spring 1968, has been an ongoing project at NBER for nearly nine years. A final report to HUD in the fall of 1971 and a subsequent NBER book describe the progress made under the first HUD grant.[1]

In November 1972 the Urban Studies group was awarded a second contract to improve the exisiting NBER Model and to use it to analyze housing abandonment, a source of great concern to HUD personnel at that time; our preliminary research efforts to develop a model version suitable for analyzing abandonment are described in a September 1973 interim report to HUD.[2]

In response to changes in HUD's priorities, we modified our research objec-

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1. Gregory K. Ingram and J. Royce Ginn, H. James Brown, and John F. Kain, "The NBER Urban Simulation Model," vol. I, "The Model Description," processed

(1968); and Ingram, Kain, and Ginn, *The Detroit Prototype of the NBER Urban Simulation Model* (1972).

2. John F. Kain, et al., "First Interim Report on Contract to Improve the NBER Urban Simulation Model and to Use It to Analyze Housing Market Dynamics and Abandonment," processed (September 1973).

tives on at least two occasions with the result that the scope and content of the completed work is far different from that outlined in our original proposal to HUD. Specifically, in the spring of 1974 HUD requested that we modify and extend our existing research contract and redirect our modeling efforts toward the analysis of the market impacts of housing allowance programs. While much of our previous efforts to adapt the NBER Model to the study of housing abandonment was useful to our new assignment, the evaluation of the market impacts of housing allowances presented us with a completely new and far more difficult set of conceptual and estimation problems. The Experimental Housing Allowance Program (EHAP) is principally concerned with short-term market impacts and particularly with the nature and extent of rent inflation that might result from implementing a large-scale housing allowance. Housing market analysts generally agreed that the maximum rent increases would occur soon after the program was introduced and that allowance-induced rent inflation would tend to dissipate as housing suppliers responded by constructing new units and by increasing the services they produced from existing structures. Unfortunately, existing and proposed versions of the NBER Model were poorly suited to the study of short-term dynamics, a capability which was, however, not essential for the proposed analyses of abandonment. Undertaking the housing allowance study thus required us to reconsider several aspects of model design already incorporated into Pittsburgh II, the version being developed to analyze abandonment. Major changes involved enrichment of the model's supply sector, greater elaboration of the market submodels, and a much more precise distinction between the production of housing capital and housing services. The resulting improvements are evident from the detailed description of model specification presented in Volume I of the final report.[3]

A futher complication in revising our research objectives was HUD's urgent need for quick answers. Our amended contract included two goals that were completely complementary in the long run, but somewhat competitive in the short run: (1) to refine the NBER Simulation Model for the purpose of analyzing housing allowances and housing abandonment; (2) to provide HUD with analyses of the probable market impacts of housing allowances for its Fall 1974 internal evaluation of housing allowances. The improbability of completing both tasks in the time allotted was recognized, and in April 1974, HUD and NBER agreed to pursue an adaptive strategy. NBER would give priority to model development in the hope that these efforts would produce a model suitable for simulations of the market impacts of housing allowances by Fall 1974. It was further agreed that we should jointly evaluate these efforts during the summer and adjust our work program to reflect our progress in model development and HUD's priorities. At the July 1974 meeting at HUD we agreed to defer model development and to concentrate our efforts on interim analyses of housing allowances. These interim analyses were presented first in a series of informal working papers and then included in a December 1974 report to HUD.[4]

Section I of the December 1974 report summarized a series of housing allowance simulations carried out using the Housing Allowance Demand Simulator (HADS) Model, adapted expressly for this purpose from the demand sector of the NBER Urban Simulation Model. The simulations were designed to evaluate the effects of alternative allowance programs on the demand for housing attributes and bundles in the Pittsburgh SMSA and to provide some indication of the likely size of allowance-induced market impacts, including possible price inflation among specific housing sub-

3. John F. Kain, William C. Apgar, Jr., and J. Royce Ginn, "Simulation of the Market Effects of Housing

Allowances, Vol. I: Description of the NBER Urban Simulation Model," processed (August 1976).

4. John F. Kain, ed., "Progress Report on the Development of the NBER Urban Simulation Model and Interim Analyses of Housing Allowance Programs," processed (December 1974).

markets. Section II of the interim report contained a similar analysis of the impact on household demand of a housing allowance program in the San Francisco–Oakland metropolitan area. This analysis, based on an econometric study of the San Francisco housing market, employed quite different estimation methods and evaluated a single housing allowance program that bore only a superficial resemblance to those examined with the HADS Model. An analysis of household mobility, program participation, and the housing choices of elderly households was presented in section III; section IV includes a series of simulations of supply-side responses to an allowance using a stand-alone supply submodel; and finally, section V described the progress to date in developing a version of the full NBER Model that would be suitable for analyzing the market impacts of housing allowances.

Following delivery of the report, the EHAP staff agreed that NBER should devote full time to model development, calibration, and execution of the previously agreed upon baseline and housing allowance policy simulations for Pittsburgh and Chicago. Because of the time and resources already expended on the interim policy analyses, however, this task required working beyond the original contract completion date at no additional cost to the government. During this period, HUD accepted our proposal to devote resources previously earmarked for the abandonment analyses to further improvements in model calibration, and requested only a brief working paper outlining how the model could be adapted to analyzing housing abandonment.

The major analyses completed under this contract are presented in the three-volume final report, "Simulation of the Market Effects of Housing Allowances." Volume 1, "Description of the NBER Urban Simulation Model," provides a detailed description of the current version of the NBER Model and its operation. Volume 2, "Baseline and Policy Simulations for Pittsburgh and Chicago," reports the results of baseline and housing allowance simulations for the two SMSAs, and "Development of the Supply Sector of the NBER Model," the last volume of the final report, includes a series of simulation experiments using two stand-alone versions of the model's supply sector; analyses of the NBER landlord surveys in Pittsburgh and Chicago; and analyses of changes in the location of new construction in those two SMSAs.

John F. Kain

8. THE NBER COMPUTER RESEARCH CENTER

Introduction

New activities at the Computer Research Center indicate a shift in emphasis toward energy research and increased attention to model validation and reliability. Work has also continued in several applied research areas as well as in the development of analytical methods, both theoretical and software.

Energy research has various aspects. The model of the Alaskan economy, on which work is being done concurrently at the University of Alaska and here under David Kresge's direction, pivots on the fiscal impact of North Slope petroleum. A new project supported by the Electric Power Re-search Institute is examining the structural and computer requirements for linking different models and is exploring options in the demands for basic energy resources, alternative conversion technologies, and impacts on the national economy. Design and implementation of new computer software to expedite complex energy modeling is now coming to fruition. The Computer Center plans to expand energy research further in the coming year, in collaboration with the MIT Energy Laboratory, by assessing the reliability of several major energy models, also with Electric Power Research Institute support.

Work on numerical methods that are fun-

damental to valid estimation has continued. A unique interdisciplinary enterprise that combines statistics and numerical analysis involves Virginia Klema at the Computer Research Center and Gene Golub of Stanford. David Gay, in collaboration with John Dennis of Cornell and Roy Welsch, has implemented semiportable, nonlinear algorithms that are at the forefront of computational procedures required for econometric applications.

Mathematical programming research has two facets. Work on integer programming, with Jerry Shapiro and Bill Northup, incorporates number-theoretic considerations with more standard methods for solving mixed integer programs. This research capitalizes on interactive computing possibilities available at the Center. The other project, a modular LP system being created by Roy Marsten and Mike Harrison, provides a valuable modeling-language capability; the modularity of this system will make it a natural test bed for algorithmic research. Both systems have significant potential in energy research.

An interest in research on model reliability is expected to gain momentum. The continuing Bureau tradition of combining a strong data orientation with analysis geared to data strengths and weaknesses has to some extent been at odds with the increased mathematical and econometric complexity of much contemporary research. Research on sensible ways of probing underlying data structure and its influence on estimated parameters began last summer. Roy Welsch and I found that perturbing data inputs of a regression problem, for instance, by deleting one row of data at a time (which can be done at slight additional cost) reveals unsuspected instabilities in coefficient estimates and can locate data segments that exert a disproportionate influence on those estimates. It turns out that "good" regression results often depend to an uncomfortable extent on extreme, or high leverage, points. It seems possible, in the spirit of diagnostic inquiry, to obtain a better understanding of the empirical foundations of multivariate processes than is feasible

with standard procedures. David Belsley has also contributed to diagnostic research by devising readily applicable ways of evaluating the sources and severity of collinearity in linear regression. While still experimental, these methods appear more promising than competing alternatives. Douglas Martin has been working on statistical tests that have greater sensitivity to a shift in regression structure over time than presently available methods.

In summary, then, more effort has been devoted to various facets of energy research than before; research on modeling fundamentals continues to be a strong thrust; and attention is more than ever focused on diagnostic procedures in regression that make it possible to relate data directly to econometric analysis.

Edwin Kuh

Energy and Environmental Research

Man in the Arctic Program

The development of policy planning models of the Alaskan economy is continuing as a joint project of the National Bureau and the University of Alaska's Institute of Social and Economic Research (ISER). This work is part of the Man in the Arctic Program (MAP) funded by the National Science Foundation. A major component of the current research is to extend the existing MAP models to analyze the effects of petroleum development on the distribution of income in Alaska. The income distribution model will be based on the results of recently completed MAP studies dealing with Alaska's manpower demands and supplies. Earnings differences among occupation classes, ethnic groups, and regions will be combined with employment estimates to project potential changes in Alaska's income distribution. Dan Seiver, who is based in Anchorage, spent several weeks at the Computer Research Center developing a preliminary version of the income distribution model. Seiver will continue his work on this model during the coming year, which he will spend in Cambridge as an NBER Faculty Fellow.

The income distribution model will also deal explicitly with the incomes of Alaska Natives. In doing so, it will consider the effects of possible changes in Native labor force participation rates and the impacts of the land and money coming from the Alaska Native Claims Settlement Act (ANCSA). A preliminary version of the necessary modeling has been completed and implemented using aggregate data to evaluate the impacts of ANCSA on the economic status of Alaska Natives. Work is also under way to develop a model of Native population growth, incorporating reasonably detailed demographic factors. The early results coming out of the Native Claims studies indicate that the impact of the ANCSA cash settlement will have minimal effect on the gap between Native and non-Native incomes; it is the land settlement portion of ANCSA that will provide the bulk of the long-range income gains. The results also indicate that programs designed to bring Natives into the projected employment structure through job training and education can be far more effective than direct cash payments in improving their economic status.

Wayne Christian has provided the TROLL programming support for all aspects of MAP activities. Bernice Jee has been responsible for coordinating the data collection and simulation analysis in the Native Claims studies. Jee has also assisted in the preparation of a book-length manuscript presenting the MAP research results to date, which was submitted to publishers this spring.

Edward Porter has constructed a first-pass model to estimate the economic impacts of petroleum development on Alaska's Outer Continental Shelf (OCS). The model focuses on the state and local government revenues generated by OCS activities and on the increased government expenditures required by the associated expansion of Alaska's population. The OCS development process itself is modeled using the technological information from the environmental impact statements produced by the federal agencies involved. Through linkages with the MAP economic-demo-graphic models, the OCS impact study traces out the induced changes in income, employment, and population throughout the state. Although the OCS model is being developed in the Alaskan context, it is being designed to be generally applicable so that it can be extended to analyze OCS developments in other areas as well.

David Kresge

Energy Model Integration and Assessment

Two projects have been undertaken during the past year dealing with the design and evaluation of computer models for energy-systems analysis. Both projects are funded by the Electric Power Research Institute (EPRI). The primary objective of the first, the energy-model integration project, is to design a framework for linking together models of individual energy sectors so as to deal with the energy system as a whole. In addition, the modeling framework would incorporate a model of the U.S. economy so that the energy analysis explicitly recognizes the key energy-economy relationships. The project is to draw, to the maximum feasible extent, on existing studies, data bases, and methodologies in designing the integrative framework.

The National Bureau's primary responsibility within the energy-model integration project, which is being conducted jointly with three other research organizations, is to design an appropriate set of interfaces to link existing models, and then to define the computer environment and operating systems required to implement such integrative energy models. Royce Ginn has outlined the characteristics of computer systems that would be appropriate for energy modeling at several different levels of complexity. In doing this, he has drawn on the expertise and software being developed in the National Bureau's energy-modeling research.

An appropriate modeling system would first need to be capable of maintaining and manipulating the data bases required to drive the major energy models now in use. Next, the modeling framework would need to provide the interfaces to handle the in-

formation flows required to operate the various models together in a common environment. Finally, the modeling system would need to carry out the analytical computations and process the inputs and outputs required by substantive energy-policy analysis. The final report on this project, which was submitted to EPRI in the spring of 1977, contains specific recommendations on the energy models which might be included within such an integrative framework and on the procedures required to implement the framework for energy-policy analysis.

The objective of the second energy project, which began in March, is to develop procedures for assessing the validity of energy models. A number of recently developed energy-system models are starting to play an important role in the process of energy-policy evaluation. However, detailed knowledge of these models is available only through the documentation that the individual modeler releases, and that documentation is often incomplete or inadequate for a full understanding of the strengths and weaknesses of the model. To provide adequate assessments of large, complex models, they must be run and tested by someone other than the original modelers. In this project, the National Bureau has been asked to develop a prototype, third-party energy-model evaluation and assessment capability. This work will be undertaken jointly with the M.I.T. Energy Laboratory.

The model which has been selected as the principal test case for the assessment facility is the Baughman-Joskow model of the electric utility industry. Royce Ginn, Wayne Christian, and Rick Wilk will put the model up on the TROLL system. National Bureau and M.I.T. Energy Laboratory personnel will then carry out detailed sensitivity analyses to pinpoint the model's critical points. In addition to the in-depth assessment of the Baughman-Joskow model, an overview assessment (not involving "hands on" operation of the model) will be made of the Wharton annual energy model. Particular attention will be given to the model's potential usefulness as a framework for linking together other, more detailed energy models. The energy-model assessment project is closely related to the work being conducted as part of the energy-model integration project.

David Kresge

Energy Modeling Software

The Computer Center has completed the control software for its energy-modeling system. The overall purpose of the system is to provide a comprehensive environment for economic analysis of contemporary energy problems. The system has been designed so that system-control software is separate from the applications (problem-solving) software; thus, the effort of implementing new applications is reduced. The control software includes the operating system ACOS (Application Control System) and the special-purpose programming languages ACOL (Application Control Language) and DASEL. The initial application software includes subsystems for creating, estimating, and simulating econometric models, and the AMPS subsystem for creating and solving mathematical programming models.

ACOS has been completed and has proved to be a flexible, reliable environment for the applications. ACOL has also been completed and has been used extensively as the command and control language for the Center's new applications. The documentation for ACOS/ACOL has been revised and is ready for outside users of the system. Walter Oney is the principal implementor of ACOS, and Annette Somers, with the aid of Mark Gelfand, Maurice Herlihy, and David Rice, has been maintaining and expanding ACOL.

DASEL, an interactive programming language for mathematical algorithms, has been used in a number of applications, including experimental regression and simulation programs, a simple linear programming system, and statistical analysis research. The DASEL reference manual has been substantially expanded to include the newest features of the language, including time series data. The functional

capabilities of DASEL have been extended by allowing FORTRAN and PL/I procedures to be called by DASEL via a user-controllable interface. A new utility allows transfer of data between DASEL and TROLL, and this facilitates both the verification of application results and the combined use of the two systems to extend existing applications. David Rice is responsible for maintaining DASEL, Maurice Herlihy and Richard Wilk have designed and coded the additions to the language, and Wayne Zafft is the principal author of the reference manual.

In the near future, the ACOS environment will be combined with that of TROLL so that the application subsystems of TROLL will be available in the energy-modeling system. Once this is done, we will have a single environment incorporating all the functional capabilities of TROLL, the command and control processing of ACOL, and the algorithm development of DASEL.

As interest in modeling energy systems has grown, the analytic and theoretical methodologies used to analyze those systems have also developed. Some of the methods involve well-understood techniques used in other research for many years; others model specific energy applications; some use new analytic tools currently being researched; and finally, others link up some combination of these techniques, models, and tools.

The ACOS environment is designed to experiment with the implementation of energy modeling. Two well-understood techniques are linear programming and regression. Mike Harrison has programmed the linear programming model editor (XME) and problem solver (XLP). An experimental model translator (matrix generator) and reporter is being coded with the aid of other support (XMP). An experimental regression-model editor and estimator has been programmed by Mark Gelfand and Maurice Herlihy. The system solves difficult nonlinear least squares problems using John Dennis' optimizer, MINOPT. The most challenging nonlinear problems will soon be solved by the state-of-the-art optimizer, DMINIMIZE, being developed at the Bureau.

A host of exploratory data analysis techniques advocated by John Tukey, Roy Welsch, and Dave Hoaglin are growing in importance. Some of these techniques have been implemented as DASEL functions by Stephen C. Peters.

Mark Gelfand
David Rice
Richard Wilk

Industrial Demand for Energy

Our research has been focused on four topics: interfuel substitution in two-digit industries; substitution among energy, capital, and labor; technical change in energy use; and the dynamic structure of energy demand.

Interfuel substitution is examined by estimating cost-share equations derived from translog unit cost functions with cross-sectional state data for 1971, 1962, and 1958. The results indicate considerable variation in energy substitution both across industries and across types of energy. Estimated own-price elasticities for all types of energy except electrical are generally substantially greater than unity.

Substitution among energy, capital, and labor is examined with data from the 1958 Census of Manufactures. Preliminary estimates of cross-price elasticities indicate considerable variation in substitution between different types of energy and nonenergy inputs. The results also indicate that energy inputs are not separable from capital and labor for all industries.

The dynamic structure of energy demand is analyzed with the Nadiri-Rosen disequilibrium model of demand for factors of production. Results include estimates of short- and long-run price elasticities as well as the time path of changes in the response to price. The response of demand for each input to excess demands for other inputs is also estimated.

Technical change in energy use is examined with time series data for primary metal industries. The results indicate that technical change has occurred through factor augmentation at unequal rates.

Research results have been reported at

the 1975 and 1976 meetings of the Econometric Society, the 1976 meeting of the Western Economic Association, and the 1976 Atlantic Economic Conference. "Energy Substitution in U.S. Manufacturing" is forthcoming in the *Review of Economics and Statistics* and "A Dynamic Model of Energy Demand in U.S. Manufacturing" has been submitted for publication.

This research, which has been conducted through the NBER office in Palo Alto and, separately, from the Computer Research Center, has been supported by a grant from the National Science Foundation-Research Applied to National Needs (RANN). The final report for the project is available as a discussion paper.

Robert Halvorsen

Regulation of the Pulp and Paper Industry

With the aid of a computer simulation model of the U.S. pulp and paper industry, we are examining several political and economic consequences of water pollution control regulation. Our research is based on two general premises.

First, environmental control policies develop in an evolutionary fashion; thus, any regulatory outcome is the product of *both* the legislative strategy followed by Congress in establishing policy and the administrative strategy of the Environmental Protection Agency in implementing policy.

Second, there are both transitory and long-run consequences of pollution control regulation for industries and regions. The intraindustry and interregional distribution of these consequences—both costs and benefits—are major inputs to this evolutionary process.

The research has required the estimation of the costs the pulp and paper industry will incur to comply with the various requirements of the 1972 amendments to the Federal Water Pollution Control Act. Current efforts are directed at the refinement of a computer simulation model that permits these marginal compliance costs, disaggregated by major product line, to interact with demand to yield higher sustainable price levels. These prices, in turn, generate cash flows and investments, which yield time paths of adjustment for prices, output, capacity, and investment for various market structure scenarios, e.g., pure competition and various oligopolistic pricing scenarios. Plant-level impacts, measured both by changes in cost and net worth, will become inputs to the political analysis.

The political analysis will utilize simple models of self-interest and more complex "log-rolling" models to identify the likely response of individual legislators to aspects of the regulatory package: timing, coverage, stringency, etc. Congressional behavior will be modeled as a function of constituents' demand for clean water, the economic impact of the regulations on the districts, the lobbying efforts of industry and environmentalists, and the institutional structure of Congress. In modeling the industry position, "perceived" self-interest (measured in terms of compliance costs) will be distinguished from "actual" self-interest (measured by simulated changes in net worth). The dynamic element enters through consideration of the behavior of industry and Congress on subsequent legislation in which standards are adjusted and agency funds appropriated.

The research results will be useful to two distinct groups: policymakers, who will benefit from an improved understanding of regulatory impacts and the evolutionary process of regulatory development, and private-sector decision makers responsible for developing corporate strategies regarding capacity decisions in increasingly regulated industries.

Robert A. Leone
John E. Jackson

Economic Modeling, Estimation, and Analytical Methods

Price Expectations and Adaptation in American Agriculture

In this study, alternative ways of estimating directly or modeling unobservable price expectations are explored. These methods are then applied to models of U.S. agricul-

ture in order to investigate the process of expectation formation and revision. One primary goal is to explore the process of expectation formation over long periods of time in order to examine the impact of exogenous events, such as changes in government policy, on the expectation process.

A major activity of this project to date has been the preparation of the data to be used. In order to study the impact of exogenous events on the formation of expectations, an extensive historical data bank is required. We have compiled cross-sectional time series data for every major American agricultural crop; the sources are published and unpublished reports of the U.S. Department of Agriculture. The data include observations by state, from 1867 to 1970, on prices, acreage planted, acreage harvested, yield, and production.

In addition to the data on field crops, we have obtained comparable data on livestock from Stephen DeCanio of Yale University. DeCanio and I are also compiling disaggregated temperature and rainfall data from various sources from the mid-1880s to the present. We are also compiling as much data as possible on factor prices and inputs, although these are more sparse than we had hoped.

The crop and livestock data are scattered through the publications and archives of the U.S. Department of Agriculture, and have never before been collected into a single unified sample. The entire data set will be available both on magnetic tape and as part of a TROLL data archive. Details of the compilation of each series, reconciliation of data anomalies, and sources will be contained in an NBER working paper which is in preparation.

The second phase of this study is the comparison of methods for the estimation of unobservable price expectations. One such method is described in my paper, "A State-Space Approach to the Estimation of Price Expectations," *Proceedings of the IEEE Conference on Decision and Control Theory,* December 1976. Alternative methods using the unobservable

component approach of Joreskog are now being explored.

The third phase of this study is the application of those methods to the large data bank that has been compiled. That phase is just beginning; results are expected next year.

Thomas Cooley

Model Validation and Reliability

The funding last summer of a two-year NSF grant has allowed us to make rapid strides in the development of sensitive, sensible tools to detect potential problems in model estimation that may be caused by the excessive influence of a few observations or by a departure from error-model assumptions.

Three techniques have been used to devise diagnostic tools: differences, decompositions, and derivatives. The first is typified by row deletion. One useful way to discover influential data points is to examine $\hat{\beta} - \hat{\beta}_{(i)}$ where $\hat{\beta}$ is the ordinary least squares (OLS) estimate for the standard linear regression model, and $\hat{\beta}_{(i)}$ is the same except that the ith observation has been removed from the data. These differences can be computed at little additional cost.

An example of the second technique is the decomposition of the covariance matrix $(X^T X)^{-1}$ into parts related to each observation, namely $(X^T X)^{-1} x_i{}^T x_i (X^T X)^{-1}$, where x_i is the ith row of X. These quantities provide another way of finding influential points and ascertaining how they affect the estimated coefficient variances.

The third technique, differentiation, can be applied in many contexts. A disadvantage of the Durbin-Watson statistic is that it does not indicate how first-order autocorrelation might affect the individual coefficient estimates. Differentiating the generalized least squares (GLS) estimates (based on a first-order autocorrelation matrix) with respect to ρ provides a way of measuring the sensitivity of the coefficient estimates to different amounts of autocorrelation.

This year our work has focused on single-equation linear models, but in the second

year we envision work on simultaneous equation and nonlinear models. A TROLL subsystem called SENSSYS, which contains a variety of diagnostic tools, has been developed and documented by Steve Peters and David Jones.

We have summarized a portion of our work on single-equation models in "Linear Regression Diagnostics" (NBER Working Paper 173).

Roy E. Welsch
Edwin Kuh

Collinearity Analysis

A new procedure can diagnose the presence of multicollinearity in data to be employed in linear regression and can assess the potential damage that such collinearity causes in the resulting least squares estimates. This diagnostic tool is now incorporated in the SENSSYS system as VARDCOM. The procedure and its theoretical foundations are described in my "Multicollinearity; Diagnosing Its Presence and Assessing the Potential Damage It Causes Least Squares Estimation" (NBER Working Paper 154). Research continues on extending these procedures to simultaneous equation and nonlinear estimators.

David A. Belsley

Simultaneous Equation Estimation

The nonlinear full-information maximum likelihood (NLFIML) and nonlinear three-stage least squares (NL3SLS) estimators, recent additions to the GREMLIN subsystem of TROLL, are being subjected to comparative testing. Preliminary results for NLFIML are encouraging; Kent D. Wall and I report on them in "Estimation of Econometric Models Using Nonlinear Full-Information Maximum Likelihood: Preliminary Computer Results" (NBER Working Paper 142). In essence, the results indicate, contrary to conventional wisdom, that NLFIML is computationally competitive with NL3SLS for small models (5 to 10 equations, 20 to 25 parameters) that are not too nonlinear. Further testing is being conducted to add nonlinear full-information-efficient instrumental variable (NLFIVE) estimation to the

GREMLIN arsenal and to examine its comparative computational advantages.

David A. Belsley

Bayesian Estimation

Beginning in the summer of 1976, Joseph B. Kadane (Carnegie-Mellon) and James M. Dickey (University of Wales) have been exploring a Bayesian approach to prediction based on the standard linear regression model. The Bayesian approach to data analysis has attracted increasing attention from economists; see, for example, the contributions in S. Fienberg and A. Zellner, *Studies in Bayesian Econometrics and Statistics* (North-Holland, 1975). Kadane and Dickey have identified several interesting families of prior distributions and have developed practical procedures for assessing these distributions for multidimensional problems.

I designed and coded the TROLL program BAYESREG as an initial experimental implementation of their computational techniques. BAYESREG examines a linear model and then, in an interview format, determines the user's prior uncertainty concerning the model parameters by eliciting assessments of the distribution of values of the dependent variable at selected values of the explanatory variables. This information is combined with the sample likelihood to deliver posterior predictive inferences.

We demonstrated these techniques at a Bayesian econometrics conference in June and have been assimilating feedback received there. Future work will extend the range of prior distributions that BAYESREG can handle and will refine the interview procedure.

Stephen C. Peters

Structural Shifts in Time Series Models

Work is now well under way on the detection and estimation of structural shifts in time series models. One problem is the development of statistics that will be sensitive to a type of structural shift which would be expected frequently in practice. Another problem is related to the estimation of time-

varying parameter models of the Kalman filter variety.

A number of test statistics can be used for the detection of structural shifts in time series regression models. Among the better known approaches are those based on Chow's F tests and the Brown-Durbin-Evans forward cusum and cusum-squared statistics. More recently, Schweder has established certain optimality properties as well as heuristic justifications for backward cusum and cusum-squared statistics. A drawback to these approaches is that they are relatively insensitive to all but rather large structural shifts. In order to overcome this shortcoming a relatively simple statistic has been developed which is optimal for detecting small shifts having specified correlation structures. The full development of this approach required the following additional work: (1) useful confidence intervals based on approximations or numerical inversion of characteristic functions, and (2) determination of the power of the test over a range of misspecified correlation structures.

The maximum likelihood estimation of economic time series models of the Kalman filter variety has recently received some attention from econometricians. The approach is useful for estimating regression models with (randomly) time-varying coefficients which would account for structural change. Although the procedure has been used in various forms, almost nothing is known about its statistical properties. We concentrated on evaluating Cramér-Rao–type lower bounds on the parameter estimates; evaluating the performance of the KF1 algorithm (a Computer Research Center algorithm) relative to the lower bounds via Monte Carlo; and studying the likelihood surface for some simple cases. Manageable forms for the Cramér-Rao bounds have been obtained, and the bounds may now be easily evaluated. This work is being done with Peter Caines of Harvard University.

Douglas Martin

Causality in Economic Models

In this study the basic theorem characterizing causal events and existing testing methods were surveyed. Two alternative testing procedures were developed to provide a unified approach toward the problem of adjustment for serial dependance. The various methods were applied to money stocks (M1 and M2) and current measures of GNP to detect possible causal relationships between money and income. A causal spectral analysis was used to examine the sources of variation in the data and to explore their lead-lag relation.

Cheng Hsiao

Errors-in-Variables Model

P. M. Robinson, of Harvard University, and I are studying the estimation of parameters in a dynamic simultaneous equation model with stationary disturbances under the assumption that variables are subject to random measurement errors. An asymptotically efficient frequency-domain class of instrumental variables estimator was developed. The procedure consists of two basic steps. First, the model is transformed in such a way that the observed exogenous variables are asymptotically orthogonal to the residual terms. The second step is an analogue of the three-stage least squares estimator except that we take explicit account of the nonlinearity in the parameters and nonuniform property of the spectral density matrix of the disturbance term. A report on this research is forthcoming in the *International Economic Review*.

Cheng Hsiao

Robust Regression

In collaboration with Edwin Kuh, Roy Welsch, and Douglas Martin, I have been studying the behavior of linear regression estimators in situations where the carriers (independent variables) contain outliers. A row of the design matrix is said to be an outlier if its removal could cause large changes in the least squares estimates of the coefficients. If an individual observation of any carrier is sufficiently large, the corresponding row of the design matrix will be an outlier, but some outliers cannot be so readily detected (that is, they are not associated with the large entries of an indi-

vidual carrier). We have developed and studied new methods for detecting outliers in the carriers, and we systematically studied several estimators that are intended to be robust even in the presence of outliers in the carriers. The most successful detection procedures are based on the singular value decomposition of the design matrix, as are the most successful estimators.

The estimators studied include those suggested by Mallows and by Andrews. All are generalizations of the robust regression M-estimator. Although all have low efficiencies with respect to least squares, if the random errors in the linear model are normally distributed, we conclude that some of them can be useful in exploratory data analysis. We find that the set of estimators studied can be divided into three classes. The first class consists of unsatisfactory estimators, and those in the second and third classes exhibit qualitatively different behavior when applied to certain data configurations. This qualitative difference can be attributed to differing assumptions used to solve regression problems that are nearly unidentified. That is, if there is a single very large outlier in the carriers, then the coefficient estimates obtained by using methods that downweight this point are very different from those obtained by methods that do not downweight. Yet in certain cases, the data alone are insufficient to determine whether the outlier should be downweighted. Thus, different methods for downweighting the outliers in the carriers can result in very different sets of coefficient estimates.

Richard Hill

Robust Statistics

Interdisciplinary research in numerical algebra, robust statistics, and reliable software is in progress. Mathematical software has been designed and developed and now serves as a vehicle of communication among participating numerical analysts and data analysts. The design and in-line documentation of the software has made its immediate use possible by numerical analysts, statisticians, and econometricians who were not involved with the research on the software or the numerical or statistical algorithms that were employed. The vehicles for testing the reliability of the software for ROSEPACK (*RO*bust *S*tatistics *E*stimation *PACK*age) were used in testing the software for nonlinear least squares. The research on nonlinear least squares was done by John Dennis, David Gay, and Roy Welsch, with the programming and technical assistance of David Coleman, Sandra Moriarty, Steve Peters, and Scott Smolka.

The research on software for robust statistical estimators has been particularly strengthened by the collaboration with Dennis, Gay, and Welsch. Collectively, we have been able to meld the vocabularies of numerical algebra, data analysis, and robust statistics to focus on the difficult problems in robust statistics that have to do with numerical and computational stability.

Our research project has been influenced and strengthened by ties between the NBER Computer Research Center and Gene Golub of Stanford University. The software has been strengthened by feedback on its use in a different computing environment by John Sununu of Tufts University. Helpful comments and several computer runs by Richard Bartels of Johns Hopkins University have helped to motivate some modifications for portability of input and output.

Next year we expect to add to our information on robust estimation. At present very little is known about perturbation theory for the L_1 norm. Golub has devised a means of experimentally computing an L_1 condition number that involves a mathematical programming problem with a complementarity condition.

In connection with the work on this project, a conference on numerical and statistical computing was held at Stanford University June 20–21, 1977. This meeting immediately preceded the June 1977 meeting of the Institute of Mathematical Statistics. We discussed research in progress that is common to numerical analysis and statistical computing with emphasis on robust statistics. Attention was focused on ill-

posed problems, unconstrained optimization, sensitivity analysis, and selection.

Virginia Klema

Nonlinear Algorithms

During the past year we conducted extensive theoretical and computational research into the solution of nonlinear least squares and nonlinear robust regression problems; we are now completing work on NL2SOL, a modular, portable, state-of-the-art computer code for the nonlinear least squares problem, which reflects the conclusions of our research. In consultation with John Dennis and Roy Welsch, and with the aid of Neil Kaden and Scott Smolka, I have tested a number of alternatives to various computational details in the basic algorithm that John Dennis designed and Mark Gelfand implemented as the TROLL segment DMINIMIZ early last year. These details relate to how we update and when we decide to use the part of the least squares Hessian that we approximate and to how we deal with negative curvature in our Hessian approximation. While we intend to explore certain questions (such as the latter) further, especially in the more general context of nonlinear robust regression, by the fall of 1976 we felt that we had made sufficient progress to warrant preparing the NL2SOL package mentioned above. Stephen Peters, with some assistance from Scott Smolka and myself and some helpful advice from Virginia Klema, has done an excellent job of preparing this package in such a way that it should be portable (easily transferred to other computers) and readily publishable. Thus, we look forward to getting feedback from users in and outside the NBER.

David M. Gay

Experimental Mathematical Programming System

The overall system on which we have been working is now called AMPS (Adaptable Mathematical Programming System). The two component parts are XMP (Experimental Mathematical Programming) and XML (Experimental Modeling Language).

XMP is an expandable mathematical programming system that is designed to be used in experimental and subservient modes. It is being written according to the structured programming methodology to ensure modularity at all levels. The first and primary component of XMP is the linear programming system XLP. Michael Harrison has written a working version of XLP in PL/I, and David Gay has installed routines for constructing and updating an LU (lower triangular times upper triangular) factorization of the basis matrix. This LU factorization uses the latest techniques for exploiting sparsity and enhancing numerical stability, and enables XLP to solve large problems. Roy Marsten is translating the XLP routines into FORTRAN to make them available to a wider range of algorithmic researchers.

XML is an innovative modeling language for specifying linear programming models in a form that is close to common journal usage. We believe that XML will make current "matrix generators" obsolete by being more convenient to use and more efficient in operation. The main components of XML are the model editor (XME), the data editor (XDE), the model translator (XMT), and the solution reporter (XSR). Michael Harrison has completed a working version of the model editor. Michael Harrison and William Northup have been working on the design of the model translator. Robert Fourer is working on the design of the solution reporter and on the ACOL interface for the model editor.

The major accomplishments this year have been the design and implementation of XLP and the design of the language specifications for XML. Next year XLP will be improved and the language processors for XML will be designed and built. Furthermore, XLP and XML will be integrated with other Computer Research Center systems so that combined mathematical programming and econometric models can be solved.

Michael Harrison
Roy Marsten

Mixed Integer Programming

Our activities of the past year in mixed integer programming have centered around research and computer experimentation

with dual methods. The theoretical foundations of these methods were extended by David Bell, William Northup, and Jeremy Shapiro in the development of a complete duality theory for pure integer programming problems and its adaptation for use in mixed integer programming. The methods have been implemented by William Northup and J. S. D'Aversa and combined with more traditional branch-and-bound methods. The implemented codes are being used as a test bed for further experimentation to achieve a more effective blending of the different algorithmic approaches to the dual problems. To this end, Bruno Simeone experimented with a new method for solving the group optimization problem underlying the dual theory. Experimenting continues with the synthesis of the dual methods and branch-and-bound, using interactive direction to test strategies for a general code. A number of applications provide the test problems, including a water resources investment problem being studied by Dorothy Elliott, and minicomputer configuration problems by Jonathan Wexler.

William Northup
Jeremy Shapiro

Other Computer-oriented Activities

NBER Computer Service

The National Bureau Computer Service (also identified as the Computer Operations Activity) is responsible for the Bureau's central computer facilities and for disseminating software developed by the Computer Research Center for Economics and Management Science (CRC). Responsibility for the central computer facilities includes coordinating the computer and data-communications requirements of all NBER offices; managing the purchase of computer time; and establishing standard rates for computer, communication, and terminal use.

In spring 1975, the Bureau contracted with Cornell University to buy a block of time on Cornell's IBM 370/168 computer. Since then, this machine has served the computing needs of all NBER research projects.

Data-communications between Cornell and the Bureau's offices have been provided by the TYMNET network. Maurice Herlihy and Charles Byron manage day-to-day operations of the Bureau's Cornell and TYMNET facilities.

The Computer Service disseminates TROLL and other products of the CRC's algorithmic research. An interactive system, TROLL had as its original purpose the estimation and simulation of econometric models. To these base capabilities were added modules for exploratory data analysis and innovative econometric applications (e.g., spectral regression, logit and probit analysis, nonlinear three-stage least squares estimation). Other CRC products that the Computer Service disseminates include FIXPOINT, a system for simplicial approximation of economic equilibriums.

The National Bureau disseminates TROLL to selected nonprofit institutions, which access the Cornell system via the network. Such dissemination has created a user community and has given the CRC valuable feedback on new TROLL modules as they emerge from various research projects.

Dissemination in the form of external usage of the Cornell machine has continued over the past year, but on a smaller scale than in the previous year. The larger outside users have included Carnegie-Mellon University, the Conference Board, the Federal Energy Administration, various Federal Reserve banks, the Massachusetts Institute of Technology, the University of Houston, the Urban Institute, and the U.S. Export-Import Bank. As a matter of NBER policy, no commercial organizations are allowed to use the Bureau's Cornell facility.

Another form of dissemination, licensing, began during the past year. Under license contracts, the NBER installs TROLL on computers of other organizations and provides ongoing maintenance support. In return, licensees pay fees, which cover the cost of system maintenance. This arrangement promotes dissemination of the CRC's computer-system research while reducing the Bureau's commitment to direct support of a

large user community. It also permits dissemination to commercial organizations (which, as noted above, were not allowed to use the Cornell facility). Further, it allows government agencies that are very large consumers of TROLL to obtain system use from government-approved vendors.

A standard license contract was developed over the past year, together with a fee structure that differentiates between commercial and nonprofit licensees. Licenses were negotiated with the Norwegian School of Economics, Princeton University, Société de Mathématiques Appliquées, Inc. (Montreal), Technical University Malaysia, TYMSHARE, Inc., and Wirtschaftsuniversität Wien (Austria). A major maintenance task in support of licensees was the preparation of TROLL-required modifications of a new release of VM/370, the operating system under which TROLL runs. Paul Bernard developed these modifications and assisted licensees with technical problems of installation and maintenance. Another maintenance task was the development of a version of TROLL that requires no modifications of VM/370.

John Kirsch

Time Series Data Bank

The year 1976 could be called the year of revisions. The Bureau of Economic Analysis revision of the national income and product accounts started a chain of revisions—Bureau of Labor Statistics wholesale price indexes, Federal Reserve System consumer credit, industrial production, and capacity utilization, Bureau of Labor Statistics employment figures, and *Business Conditions Digest* cyclical indicators. Although most economic time series have always been revised about once a year, these revisions all involved much more than the usual routine seasonal and benchmark changes. In some cases statistical changes went back to 1946; in some, concepts were changed and new concepts added. From the point of view of the data bank administrator, the use of computers by statistical agencies is at an unfortunate stage. Most agencies are capable of using computers to

insure the consistency and facilitate the handling of large and sweeping revisions of sets of data, but they are not yet sufficiently computerized to release the revised data in machine-readable form. Some agencies do provide tapes but with a considerable lag after their printed releases.

As a consequence of all this we have been kept busy revising data and documentation. A partially revised directory was issued in September 1976 and was well received by users in and out of the Bureau. However, we find that conceptual and other revisions proceed so rapidly that "supplements" consisting of new or revised pages to be inserted in the existing directory are needed almost continuously. We issued one in January and another in the spring.

In order to cope with the increased workload caused partly by the many data revisions and partly by the addition of another time-sharing vendor of daily updates, we hired Jonathan Sheer, on a part-time basis, to help Wan-Lee Hsu and Constance Lim in the updating operations. In addition, we are receiving some help in contacting issuing agencies from Joslin De Puys, of the Bureau's Washington office. This arrangement has turned out to be very useful, since it enables us to receive important materials sooner and with greater accuracy than we did previously.

Charlotte Boschan
Ann Wood

Machine-Readable Data Files

The National Bureau of Economic Research has maintained a tape library for the past three years. There are approximately two hundred reels of magnetic tape representing fifteen master or original machine-readable data files. The data include, for example, the extensive 1960 and 1970 *Public Use Samples* published by the Bureau of the Census, the United Nations commodity export files, and the comprehensive Thorndike sample file with various modifications. These files are documented, classified, and catalogued according to a system outlined in the 1975 Annual Report. Most of these data are available to NBER re-

searchers and, for a fee, to outside researchers.

During 1976 the following files were added to the tape library.

1. *National Longitudinal Survey (Parnes)* for young men from 1966–1973.
2. *National Longitudinal Survey (Parnes)* for young women 1966–1973.
3. United Nations. *Latin American Growth in Industry,* a data set acquired for Patricio Meller's study, "International Comparisons of Industrial Concentration in Latin America." This contains raw data from 1963 to 1973, collected by the United Nations for publication in *Growth of World Industry,* vol. 1, *Latin America,* by industry and country. The programs used by Meller to access and manipulate the U.N. data are also available as a machine-readable data file.
4. Although not new or recently purchased, the wholesale price index values published by the Bureau of Labor Statistics from 1962 to 1975 in machine-readable form have been added to the library.
5. The Board of Governors of the Federal Reserve System published revised industrial production data for January 1954 to March 1976. Both the machine-readable form and the paper copy are available in the library.

During July 1976 Ann Wood participated in the workshop sponsored by the University of Michigan, Institute for Social Research, at Ann Arbor, Michigan. The workshop, designed to help librarians and data managers deal with collections of machine-readable data sets, was a follow-up of the workshop and seminar we sponsored for the Conference on the Computer in Economic and Social Research, which was held at New York University in April 1974. Efforts are being made to develop logical documentation techniques acceptable to users and libraries for the establishment of a union catalog for machine-readable data files. The Bureau will continue to participate in efforts directed toward this goal.

Ann Wood

Improved Term Structure Program

During my year as an NBER fellow I have succeeded in modifying the program I wrote in 1973 for the U.S. Treasury for spline curve-fitting of the term structure of interest rates to take into account the fact that bond coupons arrive semiannually instead of in a continuous stream. This modification took longer than anticipated, partly because of the complicated taxation of the first coupon. However, it is now complete. I plan to make the new program available to business and government. In particular, I have suggested to the U.S. Treasury Office of Debt Analysis that my precise "tax adjusted par-bond yield curve" be adopted in place of the imprecise hand-fitted yield curves shown in the monthly *Treasury Bulletin.* I am now using the new program to generate time series of term structure measures of a quality previously unavailable. These series will be incorporated into the NBER tape library, where they will be available to other researchers.

J. Huston McCulloch

9. CONFERENCES, WORKSHOPS, AND OTHER PROGRAMS

Conference on Research in Income and Wealth

The proceedings of the conferences on the Distribution of Economic Well-Being (May 1974), on Price Behavior (November 1974), and on the Economics of Residential Location and Urban Housing Markets (May 1975) are in press and publication is expected by fall of this year. Papers presented at the conferences on New Developments in Productivity Measurement (November 1975) and on the Measurement of Capital (October 1976) have been revised by the authors and are being edited.

James D. Smith of Pennsylvania State University is serving as chairman for the Conference on Modeling the Distribution

and Intergenerational Transmission of Wealth, to be held in December 1977. The following papers are anticipated:

"Estimates of Nineteenth Century Wealth Distributions"—Jeffrey G. Williamson, University of Wisconsin, and Peter Lindert, University of California, Davis

"Estimates of the Distribution of Wealth in Tennessee"—William Perry, University of Tennessee

"Taxation and Distribution of Wealth"— Nelson D. McClung, U.S. Treasury Department

"Simulating Intergenerational Wealth Transmission"—Guy H. Orcutt, Yale University, and James D. Smith, Pennsylvania State University

"The Bequest Process: A Simulation Analysis for Canada"—Michael Wolfson, Treasury Board of Canada

"Changing Patterns of Inheritance"— William H. Newell, Miami University

"Personal Sector Balance Sheets"—Edward Wolff, New York University

"Wealth between Generations"—Michael Allen, University of Washington

"Intergenerational Wealth Transmission"— Paul Menchik, University of Wisconsin

As possibilities for a future conference, J. A. Sawyer of the University of Toronto is exploring the topic "foreign trade statistics," and Allan H. Young of the Bureau of Economic Analysis is considering a review of the U.S. national income and product accounts.

The conference program has been assisted by grants from the National Science Foundation. The Executive Committee consists of Clopper Almon (chairman), Laurits R. Christensen, Stanley Lebergott, Milton Moss, Joel Popkin, J. A. Sawyer, Jack E. Triplett, Dorothy Walters, Burton A. Weisbrod, Allan H. Young, and Mildred E. Courtney (secretary).

Mildred E. Courtney

Universities–National Bureau Committee for Economic Research

The Universities–National Bureau Committee held a conference on population and economic change in less developed countries at the University of Pennsylvania on September 30 through October 2, 1976. The proceedings are being prepared for publication. The planning committee for the conference consisted of Richard Easterlin, Robert Willis, Allen Kelley, and T. Paul Schultz. Richard Easterlin is the conference editor.

A conference on low-income labor markets will be held in the fall of 1977. The planning committee members are Sherwin Rosen (chairman), Orley Ashenfelter, James Heckman, and Finis Welch.

At its annual meeting on October 1, 1976, the Universities–National Bureau Committee approved the recommendation of the exploratory committee to hold a conference on the economics of information and uncertainty. George Stigler was the chairman of the exploratory committee, and John McCall is the chairman of the planning committee.

Two topics were selected for possible future conferences: (1) natural resources and (2) sources of growth in developing countries. The respective chairmen of the two exploratory committees are Harold Barnett and Irma Adelman. There is also an exploratory committee on taxation and household behavior which was appointed earlier, with Martin Feldstein as chairman.

One conference volume has been published this past summer: *Education as an Industry,* edited by Joseph T. Froomkin, Dean T. Jamison, and Roy Radner.

The Universities–National Bureau Committee accepted the University of California at San Diego as a new member. There are now forty-one universities, together with the National Bureau, represented on the committee. The participating universities are:

Brown	New York
California, Berkeley	New York State,
California, Los	Buffalo
Angeles	North Carolina
California, San	Northwestern
Diego	Ohio State
Carnegie-Mellon	Pennsylvania
Chicago	Pittsburgh
Columbia	Princeton

Cornell
Duke
Harvard
Illinois
Indiana
Iowa State
Johns Hopkins
Maryland
Massachusetts Institute
  of Technology
McGill
Michigan
Michigan State
Minnesota
New School for
  Social Research

Purdue
Queen's
Rochester
Stanford
Texas
Toronto
Vanderbilt
Virginia
Washington
  (St. Louis)
Washington
  (Seattle)
Wisconsin
Yale

Other members of the U-NB 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. Luckett. Christine Mortensen is secretary.

The conference program is assisted by a grant from the National Science Foundation.

Universities interested in membership on the Universities–National Bureau Committee for Economic Research should get in touch with the chairman of the Committee. The criterion for acceptance of a university as a member of the Committee is the extent and quality of economic research carried on at that university.

Universities wishing to be informed about proposals for future Universities–National Bureau Committee research conferences and about the availability of conference papers before publication should communicate with the secretary of the Committee.

Christine Mortensen

Conference on the Computer in Economic and Social Research

In 1976 a workshop on stochastic control was organized by David Kendrick of the University of Texas at Austin and Edison Tse of Stanford University and took place on May 26–28, at Stanford University in Palo Alto, California. About thirty economists and engineers participated in the workshop, and the major topics considered were the usefulness of imperfect models in setting macroeconomic stabilization policies, monetary policy under uncertainty, identification conditions and time-varying models, the international energy model, the project independence evaluation system, recent results in least squares estimation theory, minimax control of stochastic systems, comparison of optimization techniques for a monetary model of France, optimal pricing models for exhaustible resource cartels, identification and estimation of linear models with measurement error, the use of optimal control techniques to measure economic performance, policy models of agricultural commodity trades, generalized least squares applied to time-varying parameter models, and stochastic control for linear, discrete time, distributed lag models. Some of the papers presented at this conference are scheduled to be published in a future issue of the *Annals of Economic and Social Measurement*. The workshop was made possible by a grant from the National Science Foundation.

Two workshops have been scheduled for 1977. A stochastic control theory workshop was organized by David Kendrick of the University of Texas at Austin and Edison Tse of Stanford University and was held at Yale University, May 25–27, 1977. A Social Security research files workshop is scheduled to take place in late 1977, in Williamsburg, Virginia. The workshop will be organized by Frederick Scheuren of the Social Security Administration and Richard C. Taeuber of the Commission on Federal Paperwork.

M. Ishaq Nadiri

Conference on Econometrics and Mathematical Economics (CEME)

This conference, organized in 1970, continues its program to stimulate discussion and research on the frontiers of the state-of-the-art of econometric and mathematical economic theory and methodology and their application in empirical economic studies. The conference is organized in seminar groups which meet periodically at leading universities and research centers throughout the United States. The leaders and participants in the seminars consist of a changing set of senior and young scholars, depending on topic and research being conducted in the field.

The seminars currently active are General Equilibrium Models, Evaluation of Econometric Models, Comparison of Econometric Models, Decision Rules and Uncertainty, Optimal Economic Growth and Natural Resources, Bayesian Inference in Econometrics, Quantitative Studies in Industrial Organization, Public Economics and Nonmarket Decisions, Decentralized Economic Planning and Programming, and Global Modeling. In addition, seminars in Distributed Lags and Time Series Analysis and in Analysis of Panel Microdata, which held meetings in prior years, are expected to be reactivated during the next academic year.

Seminar groups have held seventy sessions, produced more than 240 working papers, and have published several books and numerous articles in professional journals. These have been widely circulated and have made the results of seminars widely available.

Besides its regular seminar program, the conference periodically holds special meetings on selected subjects. The next meeting of this kind, on aggregation and econometric models, is expected to be held in March 1978.

Support for the Conference since its inception has been provided by the National Science Foundation.

Gary Fromm

Seasonal Analysis of Economic Time Series

A conference sponsored by the U.S. Bureau of the Census and the NBER on Seasonal Analysis of Economic Time Series was held in Washington, D.C., September 9–10, 1976. It was attended by experts from the academic, business, and government sectors. Fourteen papers were presented and discussed. In addition, a keynote address was delivered by Julius Shishkin, the originator of the X-11 program now widely used for seasonal adjustment of economic data. Shishkin has long been associated with the NBER and the Census Bureau, and is currently Commissioner of Labor Statistics.

The full program was outlined in NBER's 1976 Annual Report. Proceedings of the conference are to be published by the Bureau of the Census and are expected to be issued in the fall of 1977.

Gary Fromm
Arnold Zellner

Conference on Public Regulation

The National Bureau of Economic Research, under a grant from the National Science Foundation-Research Applied to National Needs (NSF-RANN), has scheduled a conference on public regulation, to be held in Washington, D.C., December 15–17, 1977. The purpose is to advance both the theory and practice of regulation. A call for papers was circulated in January 1977 to universities, research centers, government agencies, and leading scholars. The announcement stated that papers should make significant new contributions which further the formulation, analysis, and evaluation of regulatory policies; should be relevant to contemporary public policy issues; and should be suitable for discussion with outstanding experts from academic institutions, business, consumer groups, and various branches of government. Some results may be immediately applicable to regulatory problems while others may suggest promising paths for additional research.

The steering committee for the conference reviewed 117 abstracts submitted in response to the call for papers and selected the following for presentation and discussion:

"Theory and Practice in Public Regulation: A Current Overview"—Roger Noll, Stanford University

"The Public Interest Component of the Supply and Demand for Regulation"—Richard O. Zerbe, Jr., University of Washington

"Income Distributional Concerns in Regulatory Policy Making"—Robert D. Willig and Elizabeth E. Bailey, Bell Laboratories

"Regulation of the Casualty Insurance Industry: Consumer Protection against Insolvencies"—Patricia Munch and Dennis Smallwood, Rand

"Regulatory Performance in Surface Freight Transportation in Australia, Canada, Great Britain and the United States"—James C. Nelson, Washington State University

"Regulation, Barriers to Exit, and Railroad Investment Behavior"—Richard C. Levin, Yale University

"A Political Economy of Business Regulation: The Case of Water Pollution"—Robert Leone and John Jackson, Harvard University

"Enforcing Administrative Rules"—Paul Downing, Virginia Polytechnic Institute–State University

"Regulation of the Multiproduct Firm: The Case of Telecommunications in Canada"—Melvyn A. Fuss and Leonard Waverman, University of Toronto

"Open Entry and Cross Subsidy in Regulated Markets"—Kenneth C. Baseman, U.S. Department of Justice

"Regulatory Entry Into the Electric Utility Industry"—Gregg A. Jarrell, University of Chicago

"The Transition to Uncontrolled Crude Oil Prices"—W. David Montgomery, California Institute of Technology

Two formal discussants are to be selected to review each paper. It is planned that the proceedings of the conference will be published.

Gary Fromm

Research Fellowships

The National Bureau's research fellowship program is intended to provide additional educational opportunities to scholars of outstanding promise, generally at an early postdoctoral stage of their careers. The fellows devote full time, usually for a year, to their research interests with access to Bureau facilities and in association with members of the research staff who are generally familiar with the types of problems being investigated. The nature of the fellow's research interests usually determines which of the National Bureau offices is most suitable for his work.

One phase of the program is the awarding of one or more 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, which has had support from the Rockefeller Foundation, has brought to the Bureau Foreign Research Fellows from universities in Africa, Asia, and Latin America.

Faculty Research Fellows for 1976–1977 were Daniel A. Graham of Duke University, Cheng Hsaio of the University of California (Berkeley), and J. Huston McCulloch of Boston College. Graham spent his fellowship period at the Bureau's office in New York; Hsaio, at the Computer Research Center in Cambridge; and McCulloch, at NBER in Palo Alto. The Foreign Research Fellow in 1976–1977 was Narongchai Akrasanee of Thammasat University, Bangkok, Thailand, who worked in the New York office. Comments by these respective fellows on their work at the National Bureau are included with the staff progress reports in the present volume.

For 1977–1978 the Faculty Research Fellows are Michael D. Hurd of Stanford University, Mieko Nishimizu of Princeton University, and Daniel A. Seiver, University

of Alaska. Hurd will pursue his interests in econometric investigations of labor market dynamics at the Center for Economic Analysis of Human Behavior and Social Institutions at the NBER offices in Palo Alto. Nishimizu will work in the Bureau's Washington office on a comparison of sectoral changes in productivity in the United States and Japan. Seiver will be at the Cambridge office, continuing his research in econo-metric models of Alaska with a view to projecting the demands and supplies of manpower and the income distributions among demographic subgroups which would result from various growth paths for the Alaskan economy.

Appointment of a Foreign Research Fellow for 1977–1978 is not expected.

Douglas H. Eldridge