This PDF is a selection from an out-of-print volume from the National Bureau of Economic Research

Volume Title: The New Realities of the Business Cyde

Volume Author/Editor: NBER

Volume Publisher: NBER

Volume URL: http://www.nber.org/books/unkn73-3

Publication Date: 1973

Chapter Title: Staff Reports on Research Underway

Chapter Author: Various

Chapter URL: http://www.nber.org/chapters/c4180

Chapter pages in book: (p. 37 - 125)

II

---

1. ECONOMIC AND SOCIAL PERFORMANCE

Productivity, Employment, and Price Levels

Introduction

These studies have concentrated in the last few years on productivity and on price behavior, with a considerable current emphasis on problems associated with inflation. Other studies bearing on inflation are discussed in the sections of this report dealing with the Bureau's monetary studies and financial studies. Closely related topics were dealt with in the Universities-National Bureau Committee Conference on Secular Inflation, held in November 1971, the proceedings of which were published as a supplement to the February 1973 issue of the *Journal of Money, Credit and Banking*.

Aside from several short papers, the Bureau publications related to this program include *The Behavior of Industrial Prices* by George J. Stigler and James K. Kindahl, published in 1970; Solomon Fabricant's essay on "Recent Economic Change and the Agenda of Business Cycle Research," Supplement to *National Bureau Report No. 8*, May 1971; and Fabricant's article, "The 'Recession' of 1969–1970," in *The Business Cycle Today*, edited by Victor Zarnowitz, the first of the Bureau's Fiftieth Anniversary Colloquium volumes. John Kendrick's *Postwar Productivity Trends in the United States* is scheduled for publication in the fall, and the volume on "A Disequilibrium Model of Demand for Factors of Production" by M. Ishaq Nadiri and Sherwin Rosen is in press.

Our research in this area has been financed by grants from the Sloan Foundation and, more recently, from the Alex C. Walker Educational and Charitable Foundation. Additional support for the studies reported on below by Phillip Cagan and M. Ishaq Nadiri has been received from the National Science Foundation.

Robert E. Lipsey

The Problem of Inflation

Sections of the volume I am completing on the problem of inflation have been presented, in a preliminary form, in various papers, as was mentioned in earlier annual reports. During the past year, another such paper was prepared for delivery in a special lecture series at the College of Business and Public Administration of New York University. Among other things, the paper connects some of the results of the National Bureau's extensive work on business cycles with an aspect of the problem of inflation discussed in the recent *Annual Report* of the President's Council of Economic Advisers, which is particularly important at this juncture in our economy's development.

The specific problem involves moving the economy, as it approaches full employment, from the rapid growth that characterizes the phase of business cycle expansion to a sustainable path of non-inflationary growth, without veering from that path into either recession or inflation. It is surprising that the lessons yielded by business cycle research, although highly relevant to this problem, have been largely neglected in current thinking and discussions concerning stabilization.

The CEA points out that "after mid-year, the

economy will be significantly closer to the zone of full potential output, and it is both probable and desirable that the rate of expansion will and should abate toward its sustainable long-run path." [1]

Such abatement is, indeed, a typical feature of a business cycle expansion. Obviously the economy cannot continue to expand indefinitely at a rate in excess of its long-term rate of growth. But the end of so rapid a rate comes, as a rule, well before the "zone of full potential output" is reached. For, as an expansion proceeds, it tends to generate restrictive forces that grow in strength. These gradually overcome the tendency of an expansion, manifest in its earlier stages, to gather momentum. The restrictive forces, then, begin to depress, to retard, the rate of increase of aggregate economic activity before a peak is reached. In all past expansions, the retardation involved a decline to a rate below the long-term rate of growth, and in the classical business cycle, in fact, to a negative rate. Expansion generates recession, as Mitchell and Burns pointed out years ago.

The restrictive forces that are strengthened by expansion and that tend to turn the expansion into a recession may be illustrated by the way productivity changes during business cycles.

Labor productivity—output per man-hour—follows a fairly typical pattern during business cycles. As an expansion proceeds, the rate of increase of labor productivity tends to decline. Around the peak—most frequently immediately afterward, but sometimes before—labor productivity may be at a standstill or even falling. During recession, however, forces are set in motion that eventually throw the balance toward a revival in the rate of growth of productivity. Before recession has come to an end, growth of productivity has resumed and is again on the rise at a better than average rate.

To what is this cyclical pattern of change in labor productivity due? It is, we may judge from various National Bureau studies, the net result of diverse factors pushing in different directions. Some tend to speed up the rate of growth of labor productivity, and some tend to slow it down. Furthermore, the relative importance of these factors changes during the cycle.

During the initial stages of a business expansion, when output is rising rapidly but is still below the level at which most establishments are designed to operate with maximum technical efficiency, increases in the percentage of capacity utilized substantially contribute to increasing labor productivity.

One reason is the "overhead" or "fixed-cost" character of a substantial fraction of the labor employed. A larger volume of output can be produced not only with more people and longer hours but also—up to a point—with more intensive or effective work on the part of the "regular hands." Output per man-hour tends to rise.

Another reason for rising productivity during an expansion is the shift from short hours per worker toward a more normal level. This reduces the waste that subnormal hours per day or days per week entail. Furthermore, new and technologically more advanced plant ordered during the preceding period of prosperity is now available to handle additional production requirements. Also, although workers are being added to the payroll, unemployment is still high, and it is not yet necessary for employers to be content with hiring a disproportionately large number of untrained workers.

As expansion proceeds, however, the percentage of capacity utilized may reach the most efficient level of use. Additional increases in capacity utilization contribute little or nothing to the further expansion of labor productivity. Also, here and there, obsolescent equipment may have been brought back into use to meet the pressure of orders. Hours of labor, which have been rising, come to exceed the normal length of the workday, and the overtime strains both workers and equipment. With unemployment now low, labor shortages make necessary the recruitment of less desirable candidates in order to fill open jobs. Furthermore, discipline becomes more difficult to maintain when overtime prevails, jobs are plentiful, and management is overworked. Shortages occur not only in the labor market but also in other markets and in transport facilities. Delays in deliveries of materials, parts, and supplies grow longer and more

[1] *Economic Report of the President, Transmitted to the Congress, January 1973*, U.S. GPO, Washington, 1973, p. 83.

frequent. In short, if labor productivity continues to rise, it does so less rapidly than before.

Eventually the business expansion ends—at least it has in the past—and a recession begins. This means declining output and also, sooner or later, less than optimal use of plant and labor. If this were the only factor, it would push labor productivity down. But accompanying the decline in output are also reversals in the conditions that tended to depress labor productivity during the preceding expansion. These developments now tend to raise labor productivity. The net effect varies from cycle to cycle because cycles differ in the relative importance of the plus and minus factors involved. Sometimes the net effect seems to be little net change in productivity; sometimes, a decline. In either case, output per man-hour generally rises less rapidly than during the preceding business expansion.

The cyclical pattern of productivity, particularly during expansion, has consequences for the control of inflation. Even if higher wage rates should be limited by wage controls—a policy that will be less and less successful as unemployment declines—we may expect to see labor costs rising because as full employment is approached and expansion slows down, output per man-hour tends to rise more slowly, if at all, as was the case in 1969. Labor cost increases will join the rises already under way in interest rates and other costs of finance and in the costs of materials. The offset provided by spreading overhead over an increasing number of units of output will shrink as output rises less rapidly. Total costs per unit will begin to rise. Profit rates will then tend to fall, as a rule, even if selling prices are free to move. Investment decisions must be adversely affected. A "growth recession" or a recession of the older variety will be upon us.

This pattern has important implications for "the re-entry problem," as it is called in Washington. I put these implications in the form of questions. Would retarding the rate of growth further by monetary and fiscal action, when the zone of potential output is being approached, strengthen the restrictive forces already making for a turn rather than just an abatement? Would such action bring on a recession even earlier than it might otherwise appear? On the other hand, would a relaxation of monetary-fiscal pressure, in order to postpone the impending recession, speed up the rate of inflation?

I hope to have a draft of the entire volume some time this fall.

Solomon Fabricant

Behavior of Prices during Inflation

My study of price behavior began with a paper circulated last year on the persistence of price increases during the 1955–59 inflation. I am proceeding with an analysis of the recent period since 1969. The latest inflation appears to have responded more slowly to demand changes, and I am comparing price behavior for the two episodes in fifteen industries to pinpoint the behavioral differences. My work complements Nadiri's econometric analysis of price adjustments, and a grant from the National Science Foundation is financing our joint project. My part entails a comparison of cyclical movements in industrial prices, output, profit margins, and wages for the fifteen industries.

I have just completed a related analysis of 84 four-digit industries for 1967–71, in which price changes were correlated cross-sectionally with cost variables and an index of concentration. It is sometimes supposed that price increases will be greater in more concentrated industries. An alternative hypothesis is that prices in more concentrated industries lag behind changes in demand conditions. In this case, price increases in the more concentrated industries would be smaller in the beginning of an inflationary movement and larger at the end as they catch up. Analysis of the 84 industries showed that the more concentrated industries did experience smaller increases in 1967–69, but that the increases did not become larger in 1970–71. This puzzling result needs further checking. If it stands up, it contradicts both of these hypotheses about the relation of concentration to price behavior. This question is of some current policy importance, because the enforcement of price controls has been limited to large firms and unions on the grounds that they spearheaded the inflation.

Phillip Cagan

A Dynamic Model of Output Prices and Input Prices in Manufacturing Industries

The purpose of this research is to examine the behavior of wholesale prices, wage rates, and costs of capital services in the 15 two-digit manufacturing industries in the postwar period. Among the subjects being investigated are (1) the interrelationships between the output prices and input prices in each industry; (2) a comparison of the determinants of wholesale prices, wage rates, and the cost of capital across industries; and (3) the effects of the increase in general price levels since 1966 on the structure of relative output prices and input prices.

The analytical framework of the study is a model in which output prices and input prices interact and are determined jointly. The feedbacks from these prices are explicitly taken into account in the model and are expected to vary across industries. The model pemits us to investigate the subjects mentioned in the preceding paragraph, the relevance of the full cost and competitive pricing models to different industries, and the dynamics of the adjustments in output prices and input prices.

The equations for wholesale price, wage rate, and cost of capital in each industry are fitted to seasonally adjusted quarterly time series data for the first quarter of 1954 to the third quarter of 1971. The preliminary method of estimating the equations is the generalized least squares method. All the necessary data have been collected and processed. The initial results for some industries suggest that there are considerable differences among them with respect to the behavior of output prices and input prices. Further refinement of the analytical model and the estimation procedures used in this study will be undertaken shortly.

M. Ishaq Nadiri

Labor Market Models and the Rate of Inflation

One empirical paper on labor markets and inflation was completed during the past year, and a second theoretical paper was begun.

The first paper, "Wage-Price Controls and the Shifting Phillips Curve," published in *Brookings Papers on Economic Activity,* No. 2 (1972), at-tempts to evaluate the relative strengths and weaknesses of recent wage-price econometric models and to use my own recent model to evaluate the effects of the 1971–72 wage-price controls.

In detailed sensitivity tests and comparisons with other models, the paper confirms most of the conclusions derived from my model and summarized in the 1972 *Annual Report.* The Phillips tradeoff curve shifted in an unfavorable direction in the 1960s: that is, a given aggregate unemployment rate is now accompanied by a greater divergence than in the 1950s between the unemployment rates of prime-age male workers and those of women and teenagers. Thus the same unemployment rate now signifies more excess demand for labor than it did in the 1950s. An unemployment dispersion index measures the shifting *structure* of the labor market, and the difference between my measure of "total" unemployment and official measures of unemployment seems to represent the *level* of labor demand better than the official unemployment rate does. In the long run, the rate of inflation is determined primarily by excess labor demand, but the slow adjustment in the price and wage equations makes the lagged effect of recent inflation an important factor during the "short run" of 1 to 3 years. The other major factors contributing to the short-run pattern of inflation are (1) a deviation in productivity from its trend value, which tends to occur whenever the rate of output growth varies; and (2) changes in personal and social security tax rates. The response to tax changes has received insufficient attention in previous studies; my calculations suggest that the average annual rate of inflation was .45 per cent higher in 1966–69 than it would have been if 1965 tax rates had remained in effect.

The only major aspect of the earlier paper that appears questionable to me at this point is the assumption of a fixed coefficient on expected inflation in the wage equation. An alternative equation has now been specified in which this coefficient is estimated to be a linear function of expected inflation that reaches unity when the inflation rate reaches 7 per cent.

An implication of my fixed coefficient model would be that a recovery of real output sufficient

to bring the unemployment rate down to around 4 per cent (the actual 1956 average rate) would cause a rate of inflation higher than that in 1969–70. Achievement of the administration's 2.5 per cent inflation target without controls would, under the conditions of this model, then require that the unemployment rate be maintained forever at about 5.2 per cent. If, however, the variable coefficient version of the model were closer to the "truth," then the policy implications would be considerably more gloomy: Inflation eventually would accelerate at any unemployment rate below 4.8 per cent.

The more theoretical paper, *"The Welfare Cost of Higher Unemployment,"* attempts to build a conceptual framework for the welfare economics of unemployment, a largely neglected subject, particularly in comparison to the very extensive literature available on the welfare economics of inflation. Lacking a widely accepted analytical framework, recent statements on the welfare cost of the cyclical increase in unemployment during the recent recession have been extremely casual. One approach has been to calculate the "Okun's Law" loss in aggregate output, which is statistically associated with a given short-run increase in the unemployment rate; e.g., an output loss of $100 billion in 1970–72 as compared to an alternative policy that would have maintained unemployment at a steady 3.8 per cent.

The paper analyzes the welfare implications of a cyclical recession in terms of a "full income" concept that includes not only market income and the value of nonmarket "home" activity imputed along the lines suggested in Becker's "A Theory of the Allocation of Time," but also the imputed value of time spent in job searching by the unemployed. In a recession the loss in market income is partially offset by an increase in hours spent at home and in seeking work, both of which have a positive imputed price. The recession, however, may also work in the opposite direction, since reduced job opportunities and lower incomes reduce the imputed price of search time and home time even for those who are not directly thrown out of work. A husband's loss of income, for instance, reduces the value of a wife's time at home because she has fewer market goods and services available to combine with her time.

In addition to this analysis of a cyclical recession that temporarily raises the aggregate unemployment rate by 1 per cent, the paper also considers the welfare costs of a *permanent* policy decision aimed at a higher unemployment rate target. Most of the Okun's Law output loss cited above is a temporary disequilibrium phenomenon that evaporates in the long run. Hours, capacity utilization, and labor force participation all decline temporarily in response to a cyclical recession but in the long run are determined by relative prices that are basically independent of the long-term unemployment rate.

The paper, when completed, will contain some rough empirical estimates that attempt to place a value on changes in the price of search time and home time, based partly on the numerous studies of the shadow price of time that have been completed by Becker and his associates, and on scattered questionnaires and field studies of job seeking by the unemployed.

Robert J. Gordon

Stability of Equilibrium when Individual Firms Adjust Prices

The question of how prices are adjusted in a competitive system when all participants take prices as given is obviously of theoretical importance. This project attempts to discover whether reasonable disequilibrium stories can be written in which there are individual price adjustments, but also a competitive ending. A related research topic involves studying the stability of general equilibrium when production and consumption are allowed to take place during the adjustment process.

The first paper issuing from this project ("Quasi-Competitive Price Adjustment by Individual Firms: A Preliminary Paper," *Journal of Economic Theory,* Vol. II, No. 2 (June 1970), pp. 195-206) set forth a very simplified model of a single market in which firms set prices, customers searched for low-price firms, and firms then adjusted prices according to the amount of excess demand they encountered. Such a model, under relatively weak assumptions, converges to the competitive point.

This investigation was extended to the case of the stability of general equilibrium in a second paper ("On Price Adjustment Without An Auctioneer," *Review of Economics Studies,* Vol. XXXIX (January 1972), pp. 1-15), a much more complicated venture.

The trouble with these models is that firms fail to realize that they are not, in fact, trying to find a flat competitive price but instead have some monopoly power. Accordingly, a third paper ("Stability and Competitive Equilibrium in Two Models of Search and Individual Price Adjustment," forthcoming in the *Journal of Economic Theory)* returns to the case of a single market and allows firms to realize what is going on. In one version, in which firms take other firms' prices as given, the model converges to a Nash equilibrium point under rather strong assumptions. In a second version, in which firms move instantly to such a point but in which firms setting low enough prices can find price equal to marginal revenue, the model ultimately converges to competitive equilibrium despite the monopolistic behavior of firms above the lowest price. Finally, the two models are tied together. Whether the story, which has a competitive ending, is plausible is open to question.

A fourth paper ("The Hahn Process with Firms but No Production," submitted to *Econometrica)* returns to the stability of general equilibrium and drops, for the time being, individual adjustment of prices. This paper shows how profit maximizing entities can be inserted into the most attractive non-tâtonnement process in the literature, the so-called Hahn process. The Hahn–Negishi result (utilities that consumers expect to receive decline out of equilibrium) is extended to show that expected profits also decline and that stability can still be proved using the decline of expected utilities.

It would clearly be possible to combine the paper just discussed with the individual price adjustment feature of the earlier papers without much difficulty. I have, however, started work in what seems a more interesting direction; namely, a model of general equilibrium in which production and consumption proceed during the process of adjustment but trading in certain commodities stops at a certain date. It is natural in such a model to assume that prices are ad-

justed quickly as closing dates approach and even more natural to suppose that this occurs because of the actions of individual participants. With firms (rather than consumers) controlling the prices and consumers doing the searching, I hope to be able to develop a relatively full-blown stability analysis along these lines.

Franklin M. Fisher

The Measurement of Durable Goods Prices

I have almost completed a full-length monograph, "The Measurement of Durable Goods Prices," which attempts to develop alternative price indexes to the official U.S. deflators for investment goods. Preliminary results on the trend of investment goods prices suggest that there has been no increase since the end of World War II, and that the impression that such an increase occurred is an illusion created by faulty government statistics. The new indexes are based on an extensive collection of new price data, amounting to an average of 600 observations per year for each of the 24 years between 1947 and 1970, or about 15,000 observations in all. The primary sources are (1) unit value indexes for narrowly defined commodities as collected in the U.S. Census of Manufactures; (2) mail-order catalog prices; (3) records of equipment purchases from individual steam-electric generating stations; (4) prices of used cars, tractors, and combines from "blue books" and "red books"; and (5) rentals on electronic computers.

Price indexes are constructed from the price quotations by two different methods. For relatively simple products, price changes are computed for pairs of adjacent years on identical models, with detailed mail-order catalog specifications and photographs used to control for changes in quality. Prices of complex products are measured by the hedonic regression technique. Hedonic studies have been completed thus far for hot water heaters, turbo-generators, outboard motors, tractors, refrigerators, automatic washing machines, and room air conditioners. These regression studies concentrate much more closely on changes in accessories and fuel economy than have earlier investiga-

tions in this area. A preliminary average machinery price index based on the work done thus far actually *declines* over the postwar period, unlike the official index, which almost *doubles*.

This collection of new data is designed to measure also the extent to which transaction prices are more sensitive than list prices to changes in economic conditions. The cyclical sensitivity of the Census unit value data is the subject of a working paper (to be included in the final monograph) "New Evidence on the Deviation of Transaction Prices from List Prices for Heterogeneous Capital Goods." First, the unit value indexes are adjusted to the maximum possible extent for shifts in product mix, using new methodology to correct for shifts in product mix within individual commodity groups. Then the hypothesis of procyclical movements in the ratio of the adjusted unit values to the wholesale price index for the same product is tested by two methods, multivariate regressions and the calculation of changes over periods approximating NBER specific cycles in production or capacity utilization. Both tests confirm the hypothesis of procyclical movements.

The aggregated ratio of unit values to wholesale price indexes (WPI) for all product groups is significantly related to both cyclical variables used in the study: (1) the ratio of unfilled orders to capacity in non-electrical machinery, and (2) the aggregated utilization rate for the products in the study. The influence of the ratio of unfilled orders to capacity occurs both during the current year and 2 years later. Thus a major conclusion is that discounting from list prices becomes more pervasive if a recession lasts several years than if the recession is short. One of the reasons why previous investigators have not confirmed the procyclical hypothesis has been their failure to allow for lagged effects.

The cycle-average technique confirms the regression results. One test involved computing the number of cycle comparisons in which the rate of change of the unit value/WPI ratio increased in an expansion compared to the preceding contraction or decreased in a contraction compared to the preceding expansion. The expected procyclical relationship occurs in 105 out of a possible 148 comparisons, and the aver-

age rate of growth in all expansions exceeds the average rate of growth in all contractions in 29 out of 40 product groups.

Robert J. Gordon

Aggregate Production Functions and the Explanation of Wages

The object of this research is to develop some understanding of the reasons why aggregate production functions sometimes work, even if the rigorous conditions for exact aggregation are not met. That an aggregate production function works means not only that it fits aggregate input-output data well—mere time trends will usually guarantee that—but that its partial derivatives approximate the appropriate input prices. Our procedure, extending earlier work,[1] is to create an artificial competitive industry of firms, each with its own stock of capital and its own individual production function. We provide this industry with an inelastic supply of labor and let the labor market find an equilibrium so that the wage equals the marginal product of labor in every firm that hires any labor. The output of each firm is then determinate. Every firm then adds an exogenously determined amount to its capital, the labor supply grows by an amount determined by a trend plus a random disturbance, and the process repeats itself.

We have accumulated a number of 20-year histories along these lines that differ in several respects, most significantly in the character of the distribution of production functions among firms. The individual firms generally have constant-elasticity-of-substitution production functions (including Cobb–Douglas), but of course not all functions have the same parameters. For each such history we can construct aggregates by summing output, employment, and a measure of capital stock across firms for each period. We can then fit various aggregate production functions to these aggregate time series and compare the marginal product of labor from the fitted function with the "actual" real wage. We

[1] Franklin M. Fisher, "Aggregate Production Functions and the Explanation of Wages: A Simulation Experiment," *Review of Economics and Statistics,* Vol. LIII (1971), pp. 305-325.

have currently begun fitting aggregate production functions to some of the sample histories.

Franklin M. Fisher
Robert M. Solow

Measurement of Economic and Social Performance

Introduction

This project, which began in May of 1972 with funding from the National Science Foundation, consists of three major parts. The first is designed to examine a series of areas that hold special promise for developing a more welfare-oriented measure of national output, for making the financial transactions part of the present accounts more functionally useful for analysis, and for developing a general framework within which economic and social performance can be monitored more effectively. The second part involves developing a methodology for merging microdata sets by identifying pairs of observations with a set of matching or common characteristics, thus creating a synthetic file covering all the characteristics in both original sets. In addition, the life-cycle characteristics of household behavior are being examined. The third part of the project involves the measurement and analysis of time-use, including a field experiment on the methodology of measuring time-use and several studies in the valuation of nonmarket time.

FRAMEWORK OF ACCOUNTS AND RELATED STUDIES

John Kendrick is well on the way toward finishing his book on total investment, which was begun earlier under different auspices. All the appendix tables are now in hand, along with documentation for these tables. The book will contain estimates of a much wider range of capital investment activities in the U.S. economy than are now included in the national income and product accounts. The basic data tables comprise various measures of gross and net investment, in current and constant prices. The text is about two-thirds complete.

Robert Eisner, who is working with a group of dissertation students and a senior colleague at Northwestern, has provided a detailed outline of a proposed volume on the framework of social accounts, with individual chapters dealing with sectors of the account system and with a number of special topics. Henry Peskin, who joined the staff in December 1972, will be concerned with integrating environmental measures into the economic and social accounts. Stanley Diller, added to the project staff during the fall of 1972, is currently engaged in establishing a framework for converting expenditures on components of automotive travel into implicit expenditures on standardized automotive service units. Separate reports from Eisner, Peskin, and Diller, among others, follow this one.

I have been working on several projects. One concerns the proper sectoring of expenditures by consumers on certain kinds of durable goods. For housing, the accounts presently contain only residential construction and do not distinguish between the household and business sectors. We are attempting to estimate new construction activities in the household sector (purchases by owner-occupiers) and in the business sector and to deal with the question of asset transfers from one sector to another. Purchasing a house usually entails buying land, and there are many conversions of housing use between owner-occupiers and others that should be treated as sectoral transfers.

Second, we have almost finished a study of the distribution of automobile purchases between the household and business sectors. The present accounts divide total automobile sales between households and business in a constant ratio (85 per cent to households, 15 per cent to business). Both vehicle registration data and independent evidence on household purchases derived from surveys suggest that the ratio of household purchases to business purchases has not been constant over the past several decades, and hence, that estimates of durable goods expenditures and personal savings by consumers need to be modified to reflect the true allocation. Both Avrohn Eisenstein and Linda Fray have worked on these projects.

A third project has been concerned with developing estimates of the social costs of unemployment. The estimates will attempt to distinguish between the foregone output type of

employment cost implied by most calculations and one that recognizes the loss of market skills associated with relatively long periods of unemployment. The idea is to treat skill loss as a decline in capital value for those who are unemployed for long periods and to attempt to estimate the capital value of this loss for the period from 1929 to the present. Moo Kai-Bai has been working on this research with me.

A fourth project involves an examination of data on insurance premiums as an indicator of certain types of disamenities associated with urban environments. The increased probability of theft, robbery, fire loss, and the like, ought to be reflected in the market place via changes in premiums for insurance coverage on insurable losses. Harold Horowitz has been investigating the possibility of obtaining data, both over time and among different locations at the same point in time, which would provide a means of estimating changes in these costs.

F. Thomas Juster

Measurement and Analysis of National Income

A manuscript has been drafted that sets forth and explains a comprehensive new set of national income and product accounts. Its main innovations involve the inclusion of all expenditures for investment in physical capital, human capital, and money, with imputations for capital gains (and losses) on the same types of capital, in the household, government, and enterprise sectors. The manuscript also features accounting for opportunity costs, along with market payments for uses of factors of production.

The basic draft of these proposed accounts was completed by Arthur Treadway in the summer of 1972. Since then, a number of documents have been prepared that fit various estimates into the framework. In particular, we have been developing a model set of accounts for 1966.

In addition, a number of working papers have been drafted on investment in human capital relating particularly to education, on the problem of allocating between intermediate and final product in the government sector, on the classification of entertainment and other services pro-

duced by the communications media, and on investment in natural resources.

Two comments were prepared for *Measurement of Economic and Social Performance* (Studies in Income and Wealth, Vol. 38). One urges that keepers of more traditional accounts be more receptive to attempts to extend economic measurement to a comprehensively conceived concept of income and output. The other discusses the relationship between the time path of "efficiency" or productivity of an asset and the depreciation in its value. It points out that even the assumption of a geometric decline in efficiency is sufficient for a geometric depreciation in value if a constant rate of discount per unit of time also is assumed. A geometric decline in efficiency, however, is not considered likely. Straight-line depreciation, the comment suggests, may after all come closest to reflecting the complex factors involved in slowing the declining efficiencies and increasing rates of discounts that characterize the returns from many of our capital goods.

Robert Eisner

National Accounting and the Environment

The purpose of this project, initiated in December 1972, is to explore possible revisions in our national accounting system in order to reflect the services of certain environmental assets for which property rights have not been established. These assets include air, water, and to a certain extent, land.

The results of the investigation will be presented in a monograph, due for completion about November 1973. This monograph will include chapters on the historical and current debate over the deficiencies of account aggregates as indices of welfare; on the need for environmental data in a national accounting system; on the implications of the theory of externalities for the accounting problem; on measurement and classification of accounting entries; on existing and proposed sources of data; on the efforts and plans of official governmental agencies to modify the accounts; and a chapter that provides quantitative examples of modified accounts.

Current research has been directed toward

a study of what the theory of externalities suggests about the design of sector accounts, the structure of a national consolidated account, and the necessary adjustments to convert gross product measures into net product measures if the accounting system includes environmental assets.

Theory suggests that if environmental assets are to be treated like other factors of production, each account describing a processing activity should be modified to include an entry on the input side that measures the imputed value of environmental asset services to processors and an entry on the output side that measures the imputed value of the damages to consumers and other processors that accrue from the use of these assets. Most of the damages result from the generation of undesirable residuals and waste products. If each physical unit of these two entries is valued according to the monetary value of the marginal unit, measured values of each entry will differ unless there exists a Pareto-optimal level of environmental asset use. Since, in general, optimal use is unlikely, these modified sector accounts will not balance.

A consolidation of the modified sector accounts yields a modified national income and product account. As is the case with the individual sector accounts, this account differs from the standard income and product account principally because of the entries that measure aggregate values of environmental asset services on the input side and associated environmental damage on the output side. The degree of difference depends on how these entries are valued, the extent to which environmental assets are allocated non-optimally, and whether there is excess capacity in environmental assets. If, for example, the demand for the services of environmental assets is satiated before capacity is fully utilized, and if these services are valued at the margin, the modified consolidated account will not differ substantially from the conventional income and product account.

The principal consideration in converting a gross product measure, modified to reflect environmental assets, to a net product measure is how to treat environmental asset deterioration. Theory suggests that there are two types of deterioration: (1) a deterioration in the physical ability of the asset to yield service, and (2) a deterioration in the quality of service yielded to any given user due to increasing demand. If environmental assets are to be treated like other assets, only the first type of deterioration should be deducted from the gross product measure when constructing the net product measure.

Henry M. Peskin

A Case Study in Output Measurement— The Value of Automotive Services

The purposes of the study are threefold: (1) to establish a framework for analyzing the interrelationships among the diverse activities associated with the use of automobiles; (2) to employ this framework in an empirical analysis of the factors governing the advisable and actual durability of automobiles; and (3) to lay the groundwork for additional studies in the automotive area, particularly studies related to road building.

With data covering various aspects of automotive utilization, we have begun to estimate a production function governing the combination of inputs capable of producing a standard automotive service unit (SASU). In addition to the usual vehicle—or passenger—mile, the SASU will embody the effects of road speed, accident probability, quality of car, cost of repair per mile, garage costs, and other factors. As relative prices of the relevant factors change, different combinations of the inputs will be used. For example, higher wage rates would provide the incentive for trading in old cars for new models in order to minimize labor-intensive maintenance. Thus, cross-sectional variation in wage rates should affect the length of time people keep a car.

The distinction between income and substitution effects both on the selection of inputs for a given SASU and on the demand for SASU's is particularly important in this study because these effects often act in opposite directions. High income is usually associated with the demand for high-quality durables, high-speed roads, high automobile density, and other objects of high-income elasticity; but it is also associated with high wages, high land values,

and dissatisfaction with negative externalities. High wages, and thus high maintenance costs (both direct costs and costs of time lost), could stimulate a preference for less durable (thus lower quality), "disposable" cars; high land values could raise parking and road costs, thus lowering quantity demanded; external diseconomies may be lowered by limiting the quantity of SASU's. Since the characteristics associated with income occur together in varying degrees at different times and places, I expect that their opposing effects can be separated empirically.

Stanley Diller

THE DEVELOPMENT OF AN ECONOMIC AND SOCIAL MICRODATA BASE

Merging Microdata Sets

The goal of this project is the development of microdata sets that will contain economic, social, and demographic information drawn from a variety of different sources. What is involved is the creation of a microdata set for the household sector of the economy that will correspond closely to the household sector in the national income accounts. Such a microdata set can be used to obtain distributions of income in terms of the social and demographic characteristics of individuals and households and can supply the data base needed for microanalytic modeling and simulation of the household sector. One of the areas in which such a data base would be useful would, for example, be in analyzing the impact of inflation and unemployment on the income of households with different social and demographic characteristics.

At the present time a large number of different microdata sets relating to individuals and households are becoming available. The Bureau of the Census has produced six 1-in-100 Public Use Samples of households and individuals that contain a wealth of economic, social, and demographic information from the 1970 Census. Each of these samples has detailed information on approximately 2 million individuals and the households of which they are a part. In order to permit comparisons with 1970, the Census Bureau has also produced a 1-in-100 household and individual sample for the 1960 Census in a similar format. The Social Security Adminis-

tration has also produced a 1 per cent sample of individuals covered by social security. This microdata set gives the work history of each individual quarterly for each year since 1957. Finally, the Internal Revenue Service has made available a tax model sample of individual tax returns stratified in such a manner as to provide information on individuals in different tax brackets. These different microdata sets contain quite different information, and it is the aim of this research project to see whether they can be combined in such a way that the resulting synthetic microdata set will fully reflect the information contained in each of the sources. Traditionally, the national accounts integrate information from different sources at some level of aggregation that the different sources have in common. In the current project, an effort is being made to retain the micro character of each of the original data sets, achieving the integration through statistical matching and merging procedures.

A paper on "The Strategy of Merging and Matching Microdata Sets" was presented at a workshop on the Merging and Matching of Microdata, sponsored by the National Bureau at Williamsburg, Virginia, May 4, 1973. The method developed in this paper used characteristics that were common to two different data sets in such a way that individual cases that most closely resembled one another could be matched with one another. The technique involved relating specific intervals of the matching variables in each data set to the distributions of non-matching variables in order to determine what intervals (i.e., classifications and/or groupings) of each of the matching variables should be utilized. Since, by definition, the relationships among intervals of a matching variable and the distributions of the non-matching variables are probabilistic, different combinations of intervals would be relevant as the matching basis for different probability levels. Sort tags of a hierarchical nature based on different levels of probability have been developed as a matching technique to ensure that observations from different data sets that resemble one another most closely in probabilistic terms will in fact be matched with one another.

The work to date has been generally oriented

toward the development of objective procedures for the synthetic merging and matching of any two microdata sets that have substantial information in common. In particular, however, the methods that have been developed are aimed at the systematic processing of very large microdata sets at moderate cost. Because of the greater density of cases, closer matches can be achieved with large microdata sets than with small data sets. On the other hand, because of the large volume of data involved, it is essential that the methods adopted be economical from the point of view of data processing and not require ad hoc handling of individual observations.

The programs for matching and merging microdata sets have been completed, and tests of the closeness of match are being run by matching large microdata sets with themselves to determine the validity of the process. By successively matching one half of a large data file with its other half using different matching variables and varying the sample densities, the validity of the matching process and its sensitivity to these various factors can be established.

Finally, considerable progress has also been made on the development of documentation and formatting systems that permit the different microdata sets to be combined in a way such that the integrity of the original files is preserved and sources of information are easily identified. The major bodies of data have all been documented and reformatted so that they are ready to be merged and matched with one another.

Richard and Nancy Ruggles

Lifetime Income Profiles

The broad aim of this study is to develop a life-cycle framework for unifying a number of indicators of lifetime contingencies or opportunities. The immediate task is to develop profiles of lifetime income.

Indicators of income by age have been developed based on cross-section and cohort data to show how expectations of income at different ages are influenced by growth in the economy as well as by experience. Differences in lifetime income expectations have been estimated for males with different levels of schooling, following the methods developed by Herman Miller, using mainly Census of Population and Current Population Survey Income data, except that my study (1) uses more cohort data based on many more 10-year spans; (2) supplies greater detail in terms of sex and race; and (3) uses data on the differential effects of economic growth on the calculations of lifetime income for different groups. This analysis covers 10-year changes in mean income from 1949 to 1959, 1956 to 1966, and 1958 to 1968.

Data for men and women, whites and non-whites, with different levels of schooling and for additional 10-year periods including 1959 to 1969 and 1961 to 1971, are also being compiled. From these different 10-year spans, encompassing roughly the past 20 years, we intend to show how lifetime income expectations have been changing. Corrections of census income data, which are notoriously poor for transfer and property income, will also be examined to determine whether they can be applied to the relation between income and age for different groups.

The construction of lifetime income indicators represents a paradigm for developing indicators of other contingencies over the life span. In a sense, of course, the first main paradigm is expectation of length of life as given in standard life tables and analyzed in mortality studies for different groups.

Hence the lifetime income profiles and their changes over time are part of a broader exploratory study designed to develop social indicators that reveal changes in a number of different contingencies of life. Those contingencies that will be explored in subsequent phases of the project for different groups in different stages of life are consumption, asset formation, and occupational experience.

Milton Moss

NONMARKET ACTIVITIES

Field Experiment on Measuring Time-Use

An experimental field study being conducted by the Institute for Social Research at the University of Michigan is proceeding about on schedule. We have already field-tested, on a very

small sample, a procedure for mechanically monitoring actual time-use and have compared the resulting distribution of time-use with the distributions yielded by the usual diary procedures. Additional methodological pre-tests are now in process, and we expect that a final test will be in the field by the fall of 1973. For the final test, we will attempt to combine the methodological work on measuring time-use with a substantive interest in the area of adult and child interaction and time involvement. The idea is to see if we can determine how the amount of time parents spend with children and the quality of that time affect the school achievement test scores of the children. A short paper outlining the pre-test results has been drafted.

John Robinson
F. Thomas Juster

Queuing and Prices

My work during the past year has been theoretical, and is expected to remain so for a while, since there are some difficult issues to solve. I have concentrated until now on showing the existence of stable queues even in full equilibrium, and as a corollary, the existence of a stable distribution of prices. My interest in this proposition stems from the fact that a stable distribution is generated for a homogeneous product without respect to the cost of acquiring information. I expect to have a preliminary paper ready in the fall.

Using the above results, I will next start developing a general theory of markets that will include "equilibrium" and "disequilibrium" situations as special cases. On the empirical side, I will be attempting to show that actual price distributions are consistent with the model.

Gilbert Ghez

Valuation of Nonmarket Time

During the past year I worked on two projects: (1) selectivity biases in wage comparisons; and (2) how children affect the family's allocation of time and goods.

During the last 50 years there have been substantial changes in the composition of the labor force. Nowhere are these changes more evident than in the changing labor force participation patterns of the secondary labor force groups—i.e., women, old people, and teenagers. These groups are characterized by partial participation and by a greater sensitivity (relative to prime-age males) to changes in the economic environment (unemployment, wages, income, etc.). The factors affecting these changes in participation (and, in particular, the participation of married women) have been widely discussed in published research on the subject. However, very little has been written about the implications of these changes for wage comparisons of these groups.

Since information is a scarce resource, there is no unique price for every good or service, but rather a distribution of prices. Thus, a job seeker expects the wage offers he will receive to vary from one employer to the next. The optimum job search strategy is to decide on a reservation wage and to continue the search until receipt of the first offer that exceeds this reservation wage. The level of the reservation wage relative to the wage offer distribution determines, on the one hand, the probability of job acceptance—i.e., the probability of employment—and, on the other, the average acceptable wage.

The average wage of workers belonging to a certain group reflects the mean of the acceptable wage offers. This mean differs from the mean wage offer whenever some offers are unacceptable to the job seeker—i.e., whenever participation and employment are less than full. The difference between the mean wage offer and the mean acceptable wage depends both on the characteristics of the wage offer distribution and on the reservation wage. Other things being equal, the lower the reservation wage relative to the mean wage offer, the greater the percentage of job seekers employed and the closer the observed average wage to the mean wage offer.

The distinction between the observed average wage and the mean wage offer is important when one tries to evaluate the market performance of the secondary groups. For some purposes (e.g., measuring the remuneration for labor services) data on the observed average wage should be used. However, when it comes to measuring productivity and opportunities,

data on the mean wage offer may be preferable; the use of data on the average observed wage may then yield biased results.

The nature of this bias, and its implication for the analysis of discrimination, wage-age profiles, the rates of return and depreciation of education, and the labor force participation of married women are discussed in "The Wage Rates of Women—A Selectivity Bias," which was completed last summer. In this paper, I suggest a method of correcting this bias and apply it to an American sample (the 1960 1/1,000 sample). The paper has been accepted for publication by the *Journal of Political Economy*, subject to some revisions.

The second part of my work concerns the evaluation of women's economic performance in the nonmarket sector. Incorporating household economic activity, and, in particular, the housewife's output into the national accounts would raise some severe conceptual difficulties. Since there is no open market for inputs and outputs in this sector, one has to rely on imputations. I have examined the evaluation of the housewife's price of time in several earlier studies. In the current study I am trying to analyze the inputs used in the household production process. During the past summer I analyzed a sample of Israeli time budgets. In the coming year I will broaden the analysis to include the expenditure side, the main focus of the study being the effect of children on consumption and time-allocation patterns, or to put it differently, the allocation of time and money in the production of child services.

Reuben Gronau

Business Cycles

Introduction

For a discussion of some of the National Bureau's new work on business cycles, see the report by Geoffrey H. Moore in Part I. Additional studies are described in the following reports.

Money

During the past year we continued to explore the common velocity behavior of the United States and the United Kingdom and their inter-relations in the 90-odd-year period beginning in 1879 and ending in 1970. Our findings are reported in full in the draft of the manuscript we are readying on "Monetary Trends in the United States and the United Kingdom."

This is the tenth year since the publication of *A Monetary History of the United States, 1867–1960*. The penultimate chapter of that book analyzed the postwar rise in velocity of money, which contrasted so sharply with the secular decline in velocity from 1867 through World War II. Much of the rise was clearly simply a reaction to the wartime decline. We concluded that the standard additional explanations—the rise in interest rates, shifts in price expectations, and improvement in the quality of savings and loan association shares—could not, either singly or all together, account for a significant part of the postwar rise. We tentatively offered an alternative explanation—namely, changing expectations about economic stability—and suggested that increasing confidence in the stability of the economy had led holders of money to lower the money balances they thought prudent to hold relative to their income. We also conjectured that expectations were approaching a plateau by 1960, the last year for which we had data, and that the rise in velocity would come to an end.

Panel A of the accompanying chart brings the velocity series up to date, although in the form of GNP velocity rather than the net national product velocity that we used in *A Monetary History*. The gross and net income series give different absolute values for the velocity, but the temporal movements are almost identical. The discussion in *A Monetary History* was concerned primarily with the velocity of M_2 (currency outside banks plus adjusted demand and time deposits at commercial banks) since that was the aggregate we took as a standard. In extending the series since 1960, we exclude from M_2 large negotiable certificates of deposit, which only became significant in later years (for a fuller discussion, see our *Monetary Statistics of the United States*, pp. 170-171). For comparison, we show also the velocity of M_1 (currency plus adjusted demand deposits), since many analysts prefer the narrower definition. For both M_1 and M_2, the velocities plotted in

Panel A. Current Quarterly Money Observations

Panel B. Money Observations Leading by Two Quarters
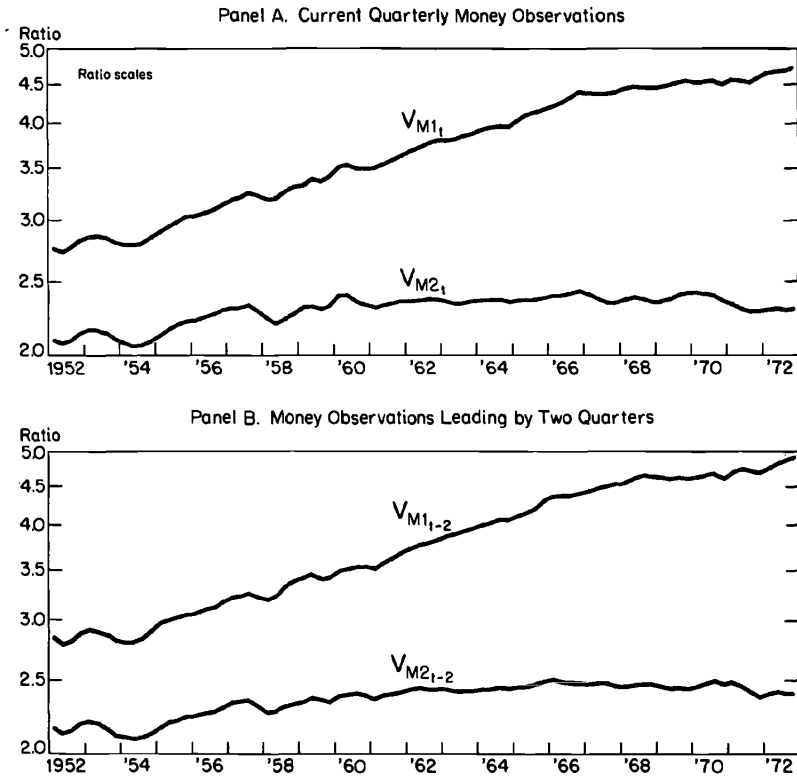
Panel A equal GNP in each quarter divided by the average daily level of the relevant monetary aggregate during the same quarter.

For M_2, the rise in velocity did come to an end very promptly after the period we covered. It reached its peak 2 years later, in 1962, and since then has been extraordinarily constant, the highest quarterly value exceeding the lowest by only 6 per cent. Although the rise in velocity did come to an end, it was not followed by a resumption of a secular decline, as we predicted in *A Monetary History*. We conjecture that the acceleration of inflation since 1962 and the associated rise in interest rates have tended to raise velocity and have thereby offset the factors, especially rising real income, that were making for a resumption of the downward trend. If, and this is a big if, inflation is reduced and interest rates fall in the next few years, velocity of M_2 can be expected to resume its downward trend.

For M_1, the picture is somewhat different. Velocity rose sharply to 1966, and then more slowly but still substantially. We are not sure that we can fully explain this result but suspect that in considerable measure it reflects the diminishing attractiveness of demand deposits relative to time deposits, given the prohibition of the payment of interest on demand deposits as the market has pushed up rates on time deposits to Regulation Q ceilings, which have themselves been raised. However, the retardation in the rate of rise of the velocity of M_1 after 1966, just when interest rates began their climb to all-time highs and the rate of inflation accelerated, suggests that the postwar rise in the velocity of M_1 as well as of M_2 may be coming to an end.

The velocities plotted in Panel A do not allow for the well-established tendency for changes in income to lag behind changes in money. To allow roughly for this difference in time, we plot

in Panel B adjusted velocities computed by dividing each quarter's GNP by the average daily level of the relevant monetary aggregate two quarters earlier. This adjustment has, of course, little effect on the trends, but it does produce smoother short-period behavior of the velocities.

Of the 44 quarterly values for the years 1962 through 1972, the highest adjusted velocity of M_2 is 2.50, the lowest, 2.37, a difference of 5.5 per cent or ± 2.8 per cent about the mean value of 2.44. The standard deviation of adjusted velocity of M_2 for these 44 quarters is 1.4 per cent of its mean value. This represents an extraordinary degree of stability for a basic economic magnitude.

<div align="right">Milton Friedman
Anna J. Schwartz</div>

Household Capital Formation

During the past year our work on consumer demand was extended for presentation at the Brookings Panel on Economic Activity. In addition, two earlier publications discussed in last year's report appeared: "Anticipatory and Objective Models of Durable Goods Demand" in the September 1972 *American Economic Review*, which will be reprinted with added appendixes by the NBER; and "Uncertainty, Expectations and Durable Goods Demand Models" in *Human Behavior in Economic Affairs: Essays in Honor of George Katona* (Elsevier, 1972).

Our paper "Inflation and the Consumer," *Brookings Papers on Economic Activity,* No. 1 (1972) updates our earlier work on durable goods demand and includes an extensive analysis of the survey data on buying intentions, consumer sentiment, and price expectations. A direct measure of expectations of inflation was constructed from Survey Research Center data for this paper. The paper reaffirms the importance of survey data for forecasting durables demand and presents prediction equations for the survey variables themselves.

We use the price expectations data to distinguish how anticipated and unanticipated inflation affect consumer behavior. It appears that the uncertainty in predicting future real incomes in inflationary periods leads consumers to retrench on spending. A further analysis of the effects of inflation on savings can be found in "A Note on Price Inflation and the Savings Rate," *Brookings Papers on Economic Activity,* No. 3 (1972). The results provide strong evidence that unanticipated inflation tends to increase savings. The paper also examines the relationship between unemployment rates and savings rates. The level of unemployment has a negative effect on savings but the change in unemployment, which we associate with an increasing concern about job security, has a positive effect.

<div align="right">F. Thomas Juster
Paul Wachtel</div>

Determinants of Investment

I am proceeding with work on a monograph based largely on the body of data from McGraw-Hill capital expenditures surveys through 1968 but involving as well the formation of sales expectations and the accuracy of sales realizations. Evidence has emerged supporting the hypothesis that expectations of sales changes over 1-year periods reflect a combination of general or longer-run anticipation of trend and a reversal of recent departures from trend. Anticipations by individual firms are fairly inaccurate indicators of firms' actual sales changes; averages of anticipations for industrial groups are more reliable indicators of average changes for these groups. Long-run (3 and 4 years) anticipated sales changes are less influenced by previous short-run movements but are almost completely inaccurate as indicators of actual sales changes. Much of this evidence may explain some of the shortcomings of traditional investment models, which assume, explicitly or implicitly, that changes in expected future demand are simple and stable, if not proportional, functions of past changes in sales or output.

Non-linear aspects of the response of investment to changes in sales have been explored. There is conflicting evidence of the parameters being higher for rising sales than for falling sales and that higher-than-average proportions of profits and depreciation flow are associated with shorter lags or faster responses of invest-

ment to changes in sales, particularly when these changes are in an upward direction.

We have analyzed some responses regarding the effects of tax incentives on business investment. Explicit tax credits appear to be somewhat less a factor than is accelerated tax depreciation, but neither operates clearly as a determinant of business investment over and beyond other factors such as past changes in sales and profits.

<div align="right">Robert Eisner</div>

Evaluation of Cyclical Indicators

This research program is a project of the Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce. Its main objective is to review the pertinent sections of the *Business Conditions Digest,* a monthly publication of the BEA, to complement and update the record, cyclical analysis, and scoring for a large collection of time series that are of great interest to economic analysts and forecasters. Contributions to the study, which is financed by the BEA, are made by the BEA staff in Washington and by members of the NBER and of the University of Chicago.

Work started in October 1972 and the study should be completed early in 1974. Victor Zarnowitz directs the project for the BEA, and shares with Charlotte Boschan of the NBER and with Feliks Tamm and other staff members of the BEA the responsibility for the analysis. Also engaged in this research at the NBER are Josephine Su and Dorothy O'Brien.

The new BEA study should benefit greatly from the knowledge and experience accumulated through the long series of past NBER efforts in this area (the first list of business cycle indicators was compiled by Mitchell and Burns in 1937). The important developments in the economy, as well as the extensions and improvements in economic statistics and analytical methods, make this the proper time to undertake another comprehensive evaluation of the system of business cycle indicators, which was last reviewed by Moore and Shiskin in 1966 (see their *Indicators of Business Expansions and Contractions,* NBER, 1967).

The list of indicators to be studied includes nearly 300 time series, about half of them presently contained in the *Business Conditions Digest* and half new. We began by applying to these series the Bry–Boschan computer program for dating cyclical turns and by reviewing the results with the aid of charts. Most of this phase of the study has been completed. After having determined the turning points, we will compute programmed measures of other relevant characteristics of the series, especially the cyclical timing, duration, conformity, and amplitudes. Our primary emphasis will be on the post-World War II period. The current reference cycle chronology of the National Bureau will be used, but subject to such revisions as the results of the analysis may indicate are necessary. The information thus developed will enable us to update the scoring system for indicators worked out in the 1966 Moore–Shiskin study and extend it to the new series. The series will be grouped by economic process. The assembled charts, measures, and scores will provide the basis for classifying by timing, evaluating, and ultimately selecting the indicators.

Some of the new issues that must be studied concern:

1. The distinction between the real and the nominal indicators. The behavior of indicator series that are expressed in physical units (or deflated) will be examined more closely in the light of suggestions that the importance of this distinction for cyclical analysis has increased during the recent period of persistent inflationary pressures.

2. The form in which some variables should be expressed: levels vs. absolute or relative changes. The timing and other characteristics of the series are decisively affected by the form chosen and the degree of smoothing applied to the series. In this context, certain stock (e.g., monetary), price, and wage variables seem to be in particular need of further study.

3. The treatment of series representing government activities and policies.

Some of the old but unresolved problems that must be reconsidered include:

4. Handling differences in timing at peaks and troughs. These differences are often systematic, but they are ignored in the present classification of indicators, mainly to simplify the presentation

of the data and to avoid additional difficulties of measurement and evaluation.

5. Differences in length of lead or lag. These differences, too, are often substantial, mainly at peaks, but it is quite difficult to recognize them systematically as the indicators are currently classified.

We should add that this study focuses primarily on the "classical" concept of business cycles underlying the NBER reference chronology rather than on the problems of "growth cycles," which have attracted considerable interest in the recent work of the Bureau and deserve much further attention.

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

Short-Term Economic Forecasting

Very limited resources were available to this area of research in the past year. However, work continued on collecting, analyzing, and interpreting forecasts from the ASA–NBER Quarterly Surveys of the Economic Outlook. Charlotte Boschan and I are jointly conducting this research.

A paper on "Macroeconomic Forecasting: Promise, Performance, and Prospect" was presented at the August 1972 annual meeting of the American Statistical Association and was published in the 1972 Proceedings of the Business and Economic Statistics Section (a revised version appeared as Selected Paper No. 41 of the Graduate School of Business, University of Chicago).

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

Public Finance

Introduction

Public finance research has made considerable headway since publication of the 1972 *Annual Report*. The essential thrust of this research program is the development of a closed-system policy analysis capability, one that can assess not only the direct consequences of alternative public policies but also incorporates indirect behavioral responses to policy actions. This approach first took concrete form in our analysis of a corporate profits-value added tax substi-

tution, which examined the differential industry price effects of this change in tax structure and then attempted to identify its probable consequences for investment, income distribution, and the balance of trade. The results of this study are reported in a manuscript authored by Stephen P. Dresch, An-loh Lin, and David Stout. A revised version of the manuscript is expected to be completed in the near future.

This large-scale-modeling effort has been significantly extended over the past year with the development of IDIOM (*I*ncome *D*etermination *I*nput-Output *M*odel), a prototype model designed to identify the consequences of basic changes in fiscal structure. Initial model development and preliminary applications were undertaken by Robert D. Goldberg and Stephen Dresch. An-loh Lin and Goldberg are now concentrating on elaborating, extending, and refining the model.

IDIOM has become a particularly useful tool because it provides a skeletal structure on which future research efforts can be based and enables concrete analysis of current policy options to be carried out. This dual capability was a conscious objective in the evolution of the model.

The present status of the model is described in the reports that follow. Over the past year, the model has been applied to the analysis of a number of specific policy alternatives, especially to policy menus incorporating major reductions in levels of U.S. military activity (strategic and general military contractions), changes in levels of international economic assistance, and introduction of the Family Assistance Plan. In the near future we plan to assess a number of potential modifications in federal tax structure.

The other major focus of NBER public policy research is on the general area of intergovernmental fiscal relations. Following Dresch's earlier analyses of the various general revenue-sharing proposals, James Hosek has prepared two papers on the subject of the Nixon Administration's special revenue-sharing proposals (viewed as alternatives to existing categorical grant programs). On a more general level, a theoretic analysis of the effects of alternative federal intergovernmental grant structures is being pursued by An-loh Lin. These studies

also are described in the following reports.

In addition to these efforts, John Bossons has continued his research on the joint distribution of income and wealth and on the differential incidence of alternative tax treatments of capital income (described in last year's reports).

Dresch, Goldberg, and Lin were ably assisted in their research by Elisa Nash and Frances Selhorst. Financial support for various facets of the public finance research has been received over the past year from the Economic Development Administration of the U.S. Department of Commerce, the Ford Foundation, the United Nations, and Bureau funds. Additional support is being sought to expand and apply the IDIOM model, which shows much promise as a policy evaluation model.

Edward K. Smith

IDIOM: Modeling the Consequences of Alternative Fiscal Policies

Over the last year significant effort has gone into developing IDIOM, an inter-industry, national-regional policy evaluation model. IDIOM is basically a two-stage model, consisting of a primary National Model and a secondary Regional Model. The National Model begins with a set of exogenous or predetermined final demands. The production required to fulfill these exogenous demands generates the incomes of labor and of capital owners. These incomes then determine endogenous consumption demands via consumption functions. The system is equilibrated when the incomes generated by the fulfillment of all final demands, including endogenous consumption, exactly induce the corresponding level of consumption.

The Regional Model is somewhat more complex, taking certain products of the National Model as predetermined while endogenously determining others. However, the Regional Model is so structured as to be consistent with the National Model.

A basic distinguishing feature of IDIOM is its level of disaggregation, identifying 86 industries, 25 occupational categories, 36 distinct types of capital goods (by 86 capital-using industries), 11 primary raw materials, and 14 effluents. Policy variables include three vectors of governmental final demands (federal defense, non-defense, and state-local), transfer payments, and four types of taxes (indirect business taxes, corporate profits taxes, and personal taxes on labor and net capital incomes). Policy analysis can be focused on changes in governmental or exogenous final demands or tax rates in association with a full range of compensatory instruments.

The model is very flexibly programmed for interactive time-sharing use on the IBM 360-67 computer. To date, the model has been employed to assess (1) the domestic consequences of alternative patterns of U.S. military expenditure contraction under a range of compensatory policies; (2) the differential regional consequences of the Family Assistance Plan; and (3) the economic implications of increased U.S. assistance to developing countries, with specific attention to the proposed postwar aid to Indochina. The results of several of these applications are contained in an annex to *Disarmament and Development,* Report of the Group of Experts on the Economic and Social Consequences of Disarmament (United Nations, 1972) and in Dresch's report (not an NBER project) to the United Nations Department of Economic and Social Affairs, "Disarmament: Economic Consequences and Developmental Potential" (December 1972). An article briefly outlining the model and its possible applications appeared in the *Annals of Economic and Social Measurement* this summer.

Stephen P. Dresch
Robert D. Goldberg

Special Revenue Sharing

Six special revenue-sharing (SRS) programs have been proposed by the Nixon Administration. These programs cover the fields of law enforcement, manpower, urban development, rural development, transportation, and education, and constitute a platform of fiscal reform affecting a total of approximately $11 billion in federal expenditures. Over the past year I have prepared two papers on the SRS proposals. In the first, I approach the SRS legislation as a set of policy substitutions. This approach is defensible in that SRS is intended to replace

a number of existing categorical grant programs, the appropriations for which will presumably be channeled to SRS. Since SRS, as proposed, would require relatively little new money (about $900 million more than was currently budgeted for affected grant programs in fiscal 1972), a major impact of the policy substitution can be expected to come through changes in the distribution of federal aid to and within states, rather than from the differential incidence of increased taxes. In the paper I (1) review the SRS proposals; (2) develop a closed framework for calculating the anticipated *change* in the amount of federal funds destined for the states if SRS replaces the designated grant programs; (3) estimate these state-level (not state-government) budget changes by state for each SRS program, both in absolute and per capita terms and under two different financing assumptions; and (4) relate the budget changes to selected economic and demographic variables, many of which are employed in the SRS allocation formulas. Intrastate budget changes are not treated in this paper, nor are any behavioral responses.

Results indicate fairly large budget changes in a number of cases; as a rule of thumb, states that did relatively well under the system of categorical grants do less well under SRS—i.e., are more likely to have a negative budget change. But I should emphasize that the distributions of calculated budget changes depend on how future grant awards, which could be expected in the absence of SRS, are predicted. These have been predicted from the recent distribution of grant awards. If one felt such predictions were unreliable or implausible, one might discount the validity of calculated state-level budget changes. Given the distributions as calculated, variables positively associated with a state's SRS award were in certain cases *negatively* associated with the state's budget change. I make no presumption whether or not this situation is in some sense undesirable but simply report it as an aspect of the policy substitution.

In the second paper, which is in preliminary form, I contrast the provisions of general revenue sharing with those of SRS. The paper also describes potential intrastate changes in the al-

location of federal aid by level of government and in the magnitude and mix of public services that might be expected under an SRS-categorical grant substitution.

James R. Hosek

Budgetary Effects of Federal Grant-in-Aid Programs

The ultimate issue in the analysis of federal grant programs is their effects on public welfare. Since federal grants are channeled to the public through state and local governments, numerous works have been concerned with the responses of the states and localities to the federal grant programs. In "Federal Grants and State Government's Expenditures and Revenues" (discussion paper, NBER), I have presented a bureaucratic-type model for determining a state's budget. The model assumes that the task of the state government is to determine a fiscal menu of expenditures and revenues that maximizes net public welfare (the difference between public welfare and public burden) subject to legal and budgetary constraints. The model treats the residents and their governmental unit as separate entities. The preferences of public officials are assumed to reflect the views of a majority of voters. Within the context of budget determination, I have examined the effects of alternative federal aid programs on state fiscal effort (taxes and debt) and on expenditures for aided functions. The effects of three types of aid programs are analyzed: matching, special (restricted but nonmatching), and general (unconditional) grants.

The effects of a general grant (or an increase in the grant) on state fiscal effort and expenditures will depend on the income elasticities of state government activities; the effects of an open-end matching grant (or a change in the matching rate) will depend on price elasticities. Whether a special grant or a closed-end matching grant effectively has the same effect as a general grant will depend on the marginal propensity of public officials to spend on the aided

functions and on the size of the grant relative to state fiscal effort. Since the effects of grants vary according to the budgetary positions of states or localities, public functions and governmental units should not be too aggregated in estimating the budgetary effects of federal categorical grants. Otherwise, the effects of restrictions imposed by the grants will be concealed and cannot be fully measured. Results based on aggregate data, therefore, may very well be useless from the point of view of evaluating specific federal policies.

The model also indicates that, *given a state's preferences,* a general grant will yield greater welfare to the state than an equal-aid special or matching grant that is effectively binding. However, since politics entails conflicts of interest, people whose interests rank high in official preference will gain at the expense of those whose interests rank lower. This analysis serves to pinpoint the political nature of budget determination at the state level and the consequences of interactions between the federal and state preferences through federal aid programs. The analysis does not imply that categorical grants ought to be abandoned because they distort a state's preferences. On the contrary, it points to the necessity of federal actions in assisting those specific public functions that would be otherwise neglected by the local governments. A well-designed system of matching, special, and general grant programs should be an important and effective federal policy instrument for maintaining efficiency of public production, achieving equity in economic welfare, and promoting national goals and priorities.

Work on modeling and estimating governmental behavior for states and localities, focusing on the effects of federal aid on state and local expenditures and revenues, also is underway.

An-loh Lin

2. URBAN AND REGIONAL STUDIES

Introduction

The NBER urban and regional studies program passed another milestone during the past year with the publication of the first monograph in a new NBER series of Urban and Regional Studies. *The Detroit Prototype of the NBER Urban Simulation Model,* by Gregory K. Ingram, John F. Kain, and J. Royce Ginn, with contributions by H. James Brown and Stephen P. Dresch, which inaugurates this new series, was published in January 1973.

The Detroit Prototype volume describes the first two versions of the NBER Urban Simulation Model—The Detroit Prototype and Pittsburgh I. In November 1972 we received a 2-year contract from the Department of Housing and Urban Development to further develop the NBER model and to apply an improved version to the problem of housing abandonment and related aspects of housing market dynamics. The current contract is the second award from HUD for development of the NBER model. Initial development of the NBER model was supported by a HUD grant during 1968–70. In the intervening period, support for model development has been provided from NBER general funds.

Substantial progress is evident in other areas as well. Two highly complementary econometric studies of urban housing markets were completed during the year, have passed staff review, and are now being prepared for review by the Board of Directors. Both Mahlon Straszheim's study of the San Francisco housing market and John F. Kain's and John M. Quigley's study of the St. Louis housing market are described in individual progress reports that follow.

A third econometric study of the Pittsburgh housing market by John Quigley is nearing completion and should be ready for staff review some time this year. H. James Brown's analysis of the moving behavior of San Francisco households, described in last year's report, continues to make steady progress toward completion.

Analyses of the determinants of industry location comprise the third major area of empirical research by the urban and regional economics study group. The studies by Robert Leone of

manufacturing industries in the New York area and by Raymond Struyk and Franklin James of the movement of manufacturing firms in the Boston, Cleveland, Minneapolis-St. Paul, and Phoenix metropolitan areas were further revised during the year, and it is hoped they can be submitted for board review during the coming year. Similarly, the study by J. Royce Ginn and Robert Leone of the linkage among water usage, water prices, and industry location for the Army Corps of Engineers, also described in last year's report, continues to make good progress. The present report also contains a brief description of a continuing study of the relation between city taxes and industry location by Roger W. Schmenner. The study by Schmenner, which was able to build on the earlier studies by Leone and by Struyk and James, will provide some preliminary econometric models of the determinants of industry location.

John F. Kain

Development of the NBER Urban Simulation Model

During the past year we have completed the documentation of the Detroit Prototype and Pittsburgh I, the first two versions of the NBER Urban Simulation Model. In addition, we have begun to develop a third version of the model, Pittsburgh II, that will eventually be used to investigate patterns of housing abandonment and to evaluate several possible housing policies. Much additional research and development will be required before Pittsburgh II will be operational; this research falls into three major work areas: extensions to the supply submodels, recalibration of the demand submodels, and computer program development.

Extensions to the Supply Submodels. To address the abandonment problem, the supply side of the model must be altered extensively. Several design changes must be made in the filtering and supply submodels, and an abandonment submodel must be added. We have developed a simple analytic representation of housing production that provides useful insights about appropriate ways to simulate housing abandonment in the NBER Urban Simulation Model.[1] For example, the model currently represents supply and operating costs in a highly aggregated manner. Our analysis suggests that the components of these costs can affect the production decisions of landlords differently and therefore should be represented separately in Pittsburgh II. Furthermore, spatial differences in supply costs can contribute significantly to housing abandonment.

In calibrating Pittsburgh II, it will be necessary for us to gather data on the extent and location of abandonment in Pittsburgh and on supply costs by neighborhood. Persistent tax delinquencies are often the first sign that investors are considering abandonment. Therefore, we are currently investigating the possibility of obtaining data on tax delinquencies from the Pittsburgh tax assessor. These data would be of considerable value in identifying current and potential abandonment in Pittsburgh.

Recalibration of the Demand Submodels. To improve the parameter estimates of the demand allocation submodel, we must first improve the definitions of the housing submarkets used in the model. In support of this objective, we have used 1970 census tract data to analyze the relation of the structure of housing prices in Pittsburgh to the various neighborhood and structure attributes. These analyses yield price estimates for a large number of discrete and reasonably homogeneous housing bundles.[2] These descriptions of Pittsburgh residential price geography will be used as data in re-estimating the submarket demand equations for the model. Before we proceed with the re-estimating, however, we are attempting to resolve a number of other important theoretical difficulties. For example, many problems remain in formulating theoretically sound and econometrically tractable housing demand or choice equations. The submarket demand equations are the behavioral touchstone of the demand sector of the model; therefore, our data analysis and econo-

[1] G. K. Ingram and J. F. Kain, "A Simple Model of Housing Production and the Abandonment Problem," paper presented at a joint A.E.A.–A.U.E.R.E.A. meeting, Toronto, December 1972, processed.

[2] J. F. Kain and W. Apgar, "Neighborhood Quality and Residential Price Geography in Pittsburgh," presented at an Econometric Society meeting, Toronto, December 1972, processed.

metric work during the next several months will center on these problem areas.

Computer Program Development. We anticipate that Pittsburgh II will include a larger number of neighborhood types, workplaces, and residence zones, and a more disaggregated representation of the supply side, than either the Detroit Prototype or Pittsburgh I. These planned extensions have forced us to re-evaluate nearly all aspects of computer programming and data storage. It now appears that a more efficient use of direct storage devices could vastly improve our ability to trace changes generated by each of the enriched submodels and improve the linkages among the various submodels. For example, a proposed change in the design of the movers and vacancy submodels will enable us to represent more meaningfully the effects of neighborhood change on individual's decisions to move and on the spatial distribution of available vacant units during each market period.

<div align="right">William Apgar, Jr.
J. Royce Ginn
Gregory K. Ingram
John F. Kain</div>

Econometric Modeling of the Housing Market

During the past year I have completed revising a manuscript titled *An Econometric Analysis of the Urban Housing Market*. This analysis focuses on the market for the existing residential stock, utilizing a large household interview, cross-sectional data base. Households' preferences for housing and neighborhood location are related to income, housing prices, transportation costs, and neighborhood racial composition. In the case of black households, discrimination barriers must also be taken into account. Supply constraints and non-price rationing also have a major impact on housing choices.

Households' preferences for housing and household incomes, together with the spatial distribution of jobs, housing stocks, transport capacity, and jurisdictional boundaries, determine the spatial variation in incomes and housing prices at a given point in time. Assuming that the residential capital stock and certain other variables are given, prices and neighbor-

hoods' incomes can be jointly determined by demand and supply conditions in each submarket.

The principal direction for extending this research involves making the model dynamic—specifying relationships over time that describe how housing stocks, racial boundaries, public services, work sites, and accessibility change. The lag structures are complex, and only very simple relationships are being utilized in my first specification. Initially, I am concentrating on neighborhood racial composition, housing stock changes, and public services tax burdens and benefits.

The basic thrust of this initial specification of dynamic relationships is to test the usefulness of larger-scale econometric models of urban development patterns. These econometric procedures are a logical extension of much of what we have learned from macroeconomic models. In addition, they hold considerable promise for analyzing relatively "short-run" changes, of 5 to 10 years' duration, a time horizon often of interest to policy-makers. Finally, these types of models complement the larger NBER computer simulation model, which focuses more on specific behavioral processes at the micro level. Much of what we have learned in our econometric models ultimately is incorporated into the larger-scale model.

<div align="right">Mahlon R. Straszheim</div>

Discrimination and Heterogeneous Housing Stock— An Economic Analysis

This project tests a number of hypotheses about the nature of housing, particularly its complexity and heterogeneity, and about the determinants of household demands for specific housing attributes. The research, which emphasized the effects of the durability and heterogeneity of the housing stock and of racial discrimination on the behavior of urban housing markets, includes econometric analysis of the determinants of home ownership; the valuation of residential services; and the demand for (or consumption of) residential services by urban households.

In all the econometric analyses, we have sought to document the effects of housing dis-

<div align="center">59</div>

crimination on housing markets and its impact on black consumers. Thus, in the econometric analyses of the determinants of home ownership, there are estimates of the impact of non-price supply restrictions on the availability of owner-occupant housing to black households. The implications of the findings for the savings behavior of black consumers are explicitly considered. Likewise, in the second section, analyses of the valuation of housing attributes explicitly evaluate the effects of discriminatory pricing on properties inside and outside the ghetto. Finally, the econometric analyses deal with the effects of racial discrimination on the level and mix of the residential services consumed by black households.

The analyses are based on a detailed sample of 1,200 households and dwelling units in the St. Louis metropolitan area. The sample includes information describing not only the socioeconomic characteristics of the households but also the features of the housing consumed. Particularly significant is the attempt we have made to measure qualitative aspects of housing. The sample thus includes detailed descriptions of the residential quality of the dwelling units, structures, parcels, blockfaces, and neighborhoods associated with the sample households.

The empirical analyses have been completed and, as stated in the Introduction, a draft manuscript has been reviewed by a staff reading committee and is now being readied for review by the Board of Directors. Two papers based on this research have been published.[1]

John F. Kain
John M. Quigley

Residential Location Decisions with Multiple Workplaces and a Heterogeneous Housing Stock

The residential location and housing consumption model now under development will be extended to an analysis of modal choice as a

component of the location decision. As discussed in last year's *Annual Report,* the analysis postulates that households choose simultaneously a location, a specific type of housing, and a way of traveling to work. The choice of physical location and of housing type are determined by the systematic substitution of housing expenditures for journey-to-work costs. We assume that the workplace and income of each household is predetermined and that the spatial distributions of existing stocks of each type of housing is given. The model, as discussed in the 1972 *Annual Report,* implies that for a chosen type of housing, each household will seek a location that minimizes the total cost or gross price (housing plus transportation cost) of that type. The model further implies that households' choices *among* housing types will be responsive to systematic differences in relative prices, but the relevant relative prices are identical to the set of minimum gross prices (one for each housing type) faced by the locating household. This set of minimum prices varies systematically across households with different workplaces and incomes. These hypotheses have been tested in some detail, and a paper reporting several findings was presented at the Toronto meetings of the Econometric Society in December 1972.

The model also implies, however, that households' choices of ways to commute are simultaneously determined—i.e., that value of travel time that determines the minimum gross price for any housing type also determines each household's choice of travel mode. This hypothesis is currently under investigation, using a large sample of household and housing data from the Pittsburgh metropolitan area.

A comprehensive draft, reporting the entire analysis, will be circulated after this part of the investigation is finished.

John M. Quigley

Industrial Water Consumption

This study is concerned with the impact of changing price, quality, and availability of water on industrial water users. Since the demand for water affects both the technical configuration of water-using processes and their location, our

[1] John F. Kain and John M. Quigley, "Measuring the Value of Housing Quality," *Journal of the American Statistical Association* (June 1970), pp. 532-548; John F. Kain and John M. Quigley, "Housing Market Discrimination, Home Ownership, and Savings Behavior," *American Economic Review* (June 1972).

study attempts to identify tradeoffs in process design, spatial location, and water use.

During the first year of this 2-year research project, which is supported by the Army Corps of Engineers, we have achieved three early objectives. First, through a series of in-depth interviews in the heavy water-using industries, we have familiarized ourselves with the water problems plant managers face. Most striking of these is the difficulty in complying with constantly changing and occasionally conflicting environmental quality regulations. Second, we have analyzed available historical data on water usage as well as data on the changes in the location of water-using activity. The first analysis, based on data from the special censuses on water use, indicates that industry is continually and dramatically changing its water usage over time. Between 1954 and 1968 gross water used in U.S. manufacturing increased by 70 per cent, while intake water increased by only 17 per cent. Gross water applied per unit output decreased by 7 per cent.

Several factors have contributed to these changes. The modernization of technological processes in new plants is one factor. Changes in the price of water, as well as changes in availability and quality, have also had some effect. In this case, for example, stricter water pollution controls have, in many instances, substantially increased the cost of water. In some plants total water costs were in the range of 5 cents per thousand gallons only 10 years ago, whereas today, due to high effluent treatment costs, a per thousand gallon cost of $1.00 to $1.50 is not unusual. Even with relatively small fluctuations in water demand, we anticipate that price changes of this magnitude will have a substantial effect on water usage in the future.

The analysis of location trends lends only marginal support to hypotheses suggesting that water is an important location determinant. Preliminary findings indicate that water is a necessary but not a sufficient, condition for the continued growth of water-using industries. Geographic patterns of industry location show only slight shifts toward areas more favorably endowed with water resources.

The third objective of our first year of research involved further development of a research strategy and the cultivation of the data sources necessary to achieve our research objectives. Our objective for the coming year is to estimate a derived demand for gross water applied and intake water based on a simple model of industrial water use. The model assumes that there are essentially two production functions in water-using industries, one that produces final output using gross water and another that produces gross water through the recirculation of intake water.

To estimate this model, we are in the process of acquiring establishment-level data on water use from the Corps of Engineers and the Environmental Protection Agency. These data, on approximately 6,000 establishments, will be augmented by various other industry and government data sources.

As for location considerations, our preliminary research suggests that water for transportation may be a more important location determinant than water for processing. To test this hypothesis we are attempting to identify all waterway plant locations for plants in our sample. If feasible, this information will be subjected to a discriminant analysis to determine whether the probabilities of waterside plant locations are more strongly affected by transportation or process-water considerations.

J. Royce Ginn
Robert A. Leone

City Taxes and Industry Location

The impact of central city-suburb tax differentials on the location of manufacturing establishments is of no small concern to city administrators. The fear they share is natural: Tax increases force industry out of the city, necessitating, in turn, still more tax increases.

The present study attempts to isolate tax differential effects from other more natural effects such as transportation, labor force location, space availability, and the level of local government spending. The city-suburb tax differentials in the sample include both property tax and municipal income tax differentials. Various hypotheses regarding these different kinds of taxes are tested.

Locations and location changes of individual manufacturers have been identified for the time period 1967–71 for the metropolitan areas of Cleveland, Cincinnati, Kansas City, and Minneapolis-St. Paul. The source of these individual observations is the Dun and Bradstreet market identifiers information file, augmented by data from local chambers of commerce and state departments of industrial development. Other data for the model estimates have been supplied by local agencies.

The study is nearly complete. The bulk of the model estimations have been made. It remains only to explore some alternative model specifications.

Roger W. Schmenner

3. HUMAN BEHAVIOR AND SOCIAL INSTITUTIONS

A Concerted Research Program

Introduction

One clear lesson of the past decade is that the expenditure of huge sums of money does not guarantee the alleviation of deep-rooted social problems. The success of policies and programs intended to improve health, reduce crime, raise knowledge, or reduce the incidence of poverty requires an understanding of the behavior of individuals and the functioning of institutions such as hospitals, courts, and schools. To help increase this understanding and to provide training for those who wish to devote their research efforts to these problems, the NBER has created a Center for Economic Analysis of Human Behavior and Social Institutions.

The "Human Behavior Center" encompasses five of the National Bureau's ongoing programs of research: (1) education and information, (2) health, (3) income distribution, (4) law, and (5) population and family economics. The Center is distinct within the National Bureau in a substantive, not a physical or geographical, sense. The staff currently includes a group of economists with similar research interests engaged in a concerted and long-term program of research. Some of its members are based in the National Bureau's New York office; others are affiliated with various universities around the country, including a sizable group at the University of Chicago. Several from the New York staff will participate in the development of the National Bureau's West Coast office beginning in 1974.

Intellectual Roots

In two respects the Center's research programs reflect important extensions in the scope and focus of economic research. First, economics has often been described as the science of wealth. Traditionally, the focus has been on the production of capital goods, and the ownership of land, physical labor, and capital goods—an emphasis on tangible wealth. The Center's research, however, is concerned primarily with the intangible wealth of society. Much of this wealth is embodied in human beings—in their health, their skills and knowledge, their ability, and motivation. Equally important and perhaps even less tangible is the wealth embodied in public and private social institutions such as the legal system, the political system, churches, hospitals, schools, business firms, and private families. The creation of this wealth in human beings and in social institutions, its contribution to total production (defined broadly), its influence on human behavior and on the allocation of resources and the distribution of income— these topics are central to the Center's research interest.

Second, much of economic research traditionally has focused on the costs of production and the exchange of ownership of assets through organized markets. Much of human behavior, however, occurs outside of formal markets, yet involves situations in which choices must be made and scarce resources allocated. Economic analysis has much to contribute toward an understanding of this behavior. Perhaps the most distinguishing characteristic of the Center's research effort is the application of the familiar tools of economic analysis of production and distribution theory to aspects of human behavior for which no formal markets exist. Indeed, the whole range of human action

from birth to death is amenable to this analysis. The Center's research suggests that economic analysis can provide valuable behavioral insights related to fertility, marriage, schooling, migration, health, labor force association, crime, poverty, and other questions of considerable social interest.

By focusing on the analysis of intangible wealth and non-market behavior, the Center's research fits quite comfortably into the long-standing objective of National Bureau research: to provide more adequate quantitative measures of the economic performance of society. Initially, the National Bureau's research focused on the quantitative measurement of physical wealth and national income and thereafter sought to improve the measurement of production, productivity, and the trends and cyclical behavior in output. A shift in research emphasis toward the quantification and analysis of intangible wealth and nonmarket behavior partly reflects the success of that early effort.

Likewise, a group of researchers focusing on a set of interrelated and complementary research topics is also in the tradition of the National Bureau. Consider Wesley Mitchell's discussion of the motivation for creating the National Bureau:

> Of course, this attempt to develop economics as an objective science of human behavior through the use of mass observations labored [at the time of World War I] under a material handicap. Speculating about what it is to the interest of men to do under imagined conditions can be carried on by a lonely thinker in his closet. He requires no staff of assistants, and no financial aid beyond a living salary. In contrast, the investigator who tries to utilize observations is in the position of an experimental scientist. He must have a laboratory, specialized equipment, and assistants. Lonely thinkers can and do make contributions in this field, but they must confine themselves to problems that require relatively few and easily accessible data. Larger undertakings call for teamwork. And the largest undertakings are often the most significant (1944 NBER Annual Report).

Today's technology requires even longer-term planning, larger and more complex data sets, and still more specialized equipment.

Much of our research effort builds on the theoretical foundations and important empirical insights contained in Gary Becker's analyses of economic discrimination, fertility behavior, human capital, time allocation, and criminal behavior. Becker is the Center's Research Policy Advisor and, in addition, is an active member of the research staff in the population and law programs. The Center also draws heavily on the work of another long-time National Bureau Senior Staff member, Jacob Mincer, through his important contribution to the analysis of the personal income distribution, the labor force behavior of married women, the measurement of on-the-job training, and the relevance of opportunity costs. Mincer is currently engaged in research in the Center's program areas of education and income distribution. His forthcoming book, Schooling, Experience, and Earnings, is an outstanding contribution to an understanding of the determinants of the distribution of income in the United States.

In addition to Becker and Mincer, the Center's staff includes two other long-time members of the National Bureau's Senior Research Staff. George Stigler, whose contributions to the economic analysis of both human behavior and social institutions are well known, is active in the law and economics program. Victor Fuchs, an NBER Vice President–Research, is the Director of the Center. His earlier research on the productivity and growth of the service industries in the U.S. anticipated and influenced the Center's emphasis on intangible wealth, and he is currently pursuing his research on the economic determinants of health and the cost of medical care.

Basic Research Program

With the creation of the National Bureau's Center for Economic Analysis of Human Behavior and Social Institutions in the summer of 1972, several distinct although highly interrelated research program areas have been developed, each administered by a program director. In the staff reports that follow this introduction, the program director indicates the general focus of research in his program area. We have initially combined the two program areas of "education and information" and "income distribution" under the co-direction of Finis Welch and

Robert Michael. These areas encompass our research on the determinants of the distribution of earnings, the analysis of poverty, the analysis of earnings and labor supply behavior over the life cycle, the effects of schooling quality on earnings, and the relationship between formal schooling and information in both a market and nonmarket context.

Within the past year three National Bureau volumes have been published that are related to research conducted in this program area. *Human Resources* (Colloquium VI, General Series No. 96) includes an extensive survey by Theodore W. Schultz of recent research on human capital both within the National Bureau and elsewhere. Robert Michael's *The Effect of Education on Efficiency in Consumption* (Occasional Paper 116) analyzes the influence of formal schooling on production within the nonmarket sector. Paul Taubman and Terence Wales' *Mental Ability and Higher Educational Attainment in the Twentieth Century* (Occasional Paper 118) investigates time trends in the proportion of high-ability students attending college.

Several publications are expected within the next year. These include the Mincer volume, *Schooling, Experience and Earnings,* mentioned above; a volume by Barry Chiswick, *Income Inequality: Regional Analyses Within a Human Capital Framework;* Gilbert Ghez and Gary Becker's volume, *The Allocation of Time and Goods Over the Life Cycle;* and Paul Taubman and Terence Wales' *Higher Education: An Investment and a Screening Device.* In addition, a closely related conference volume edited by F. Thomas Juster, *Education, Income, and Human Behavior,* published jointly with the Carnegie Commission on Higher Education, will be published late this year or early next year. Several other volumes are expected to be in draft form within the next few months, so a relatively large research output in these program areas is expected within the next year or so. Over the past year the research in these two areas has been supported by grants from the National Science Foundation, the Office of Economic Opportunity, and the Office of Education. More recently, the Rockefeller Foundation has provided the Center with support for its research programs in the areas of education and information, and the distribution of income.

The Center's program on research in law and economics is directed by William Landes. Over the past year several important articles by NBER staff members have appeared in the major journals in law and economics. A collection of recent articles by members of this program staff, edited by Becker and Landes, is expected to be published within the next year by the National Bureau. This important and relatively new research program has, for the past two years, been supported by the National Science Foundation.

The health economics program is directed by Michael Grossman. National Bureau publications in this area within the past year include Grossman's *The Demand for Health: A Theoretical and Empirical Investigation* (Occasional Paper 119) and the first volume in the Center's new series, Victor R. Fuchs, editor, *Essays in the Economics of Health and Medical Care* (Human Behavior and Social Institutions, Vol. 1). Grossman's work emphasizes that health is a form of human capital investment produced in the nonmarket sector by individuals utilizing their own time as well as market-supplied medical care. The Fuchs volume contains several essays written by members of the health program and pertaining to various topics in the demand and supply of medical care, an analysis of differences in mortality rates, and essays on the health services industry. Another volume, by Victor Fuchs and Marcia Kramer, *Determinants of Expenditures for Physicians' Services in the United States 1948–68* (Occasional Paper 117), was published jointly with the U.S. Department of Health, Education and Welfare. This program of study has been supported for several years by the National Center for Health Services Research and Development. Recently the Robert Wood Johnson Foundation has provided the Center with funds for research, training, and research dissemination in the health economics program area.

A fifth program area, population and family economics, is directed by Robert Willis and encompasses our research in the areas of the economic analysis of fertility behavior and fam-

ily formation. With the co-sponsorship of the Population Council, the National Bureau is sponsoring two fertility conferences, the first of which has been published as a supplement to the March–April 1973 issue of the *Journal of Political Economy*.

The second conference was held in June of 1973 and these proceedings also will be published. Professor Theodore W. Schultz of the University of Chicago chaired the conferences and edited the conference volumes. For the past 2 years the National Bureau's research in population economics has been supported by the Ford Foundation. More recently, the National Institute of Child Health and Human Development of the Department of Health, Education and Welfare has provided support for a significant portion of this research effort.

Other Programs

The staff reports that follow indicate the specific research projects currently underway by members of the Center's staff. Notice the considerable interaction and complementarity among them. Reder's research on medical malpractice exemplifies the interactions between our law and health programs; Kramer's study of the demand for abortion and the Michael–Willis study related to fertility control emphasize the complementarity between our population and health programs; Grossman's study of the relationship between education and health deals with another important interaction between two of our program areas.

The Center's program areas are also closely related to other ongoing research programs within the National Bureau. These include the program on the measurement of economic and social performance, which draws on and contributes to our research, particularly through the study of the measurement of nonmarket production activities and the handling of large-scale microdata sets. The analyses of changes in productivity, employment, and output; the study of urban migration and housing markets; and the Computer Research Center's work in large-scale data analysis all are complementary with the Center's research program.

Since many of our areas of study are also the subject of investigation in other disciplines, the Center encourages fruitful interdisciplinary research efforts. Our current staff includes a physician, Dr. Edward F. X. Hughes, of Mount Sinai School of Medicine, and a lawyer, Richard A. Posner of the School of Law, University of Chicago. These staff members and scholars from other disciplines in the social sciences and the biological sciences provide an important breadth to our research effort.

Research and training in research are highly complementary activities. Accordingly, the Center usually has several pre-doctoral and post-doctoral fellows actively involved in research under appropriate supervision. The Center currently has on its staff five pre-doctoral fellows. It is expected that the Center will, in addition to training economic researchers, accept as fellows other social scientists who want to become competent in economic analysis relevant to their interests. One of the important functions that the National Bureau traditionally has performed has been identifying young research scholars with high potential and providing them with resources, encouragement, and direction. We expect the Center to play an important role in this Bureau-wide activity.

Another extremely important activity in which the Center expects to play a leading role is in improving the channels through which research findings reach a wider audience. Conducting high-quality research is only a part of our task; the other is to make certain that these results— be they analytical findings, methodological improvements, or useful new data sets—find the appropriate audiences. The National Bureau has experimented extensively with various techniques for disseminating research results, including publishing books, monographs, articles, and conference volumes; sponsoring conferences and workshops; and providing data sets and data banks. Within the next few years, the Center intends to explore and develop new and innovative techniques for the dissemination of research findings.

Many of the most significant areas of research now underway within the Center were begun on a small scale as exploratory efforts by one or another member of the staff. It is perhaps the most important dividend of the National Bureau's model of research effort—the long-term

commitment to a research topic by a group of researchers—that exploratory research is undertaken. The scope and the focus of the Center's research effort should continue to provide an opportunity for these important exploratory studies. Recent grants to the Center from the Rockefeller Foundation and the Robert Wood Johnson Foundation, both mentioned earlier, provide the opportunity to engage in important training and dissemination activities as well as the core support necessary to undertake a few well-chosen exploratory studies.

Administration

As mentioned, the Center for Economic Analysis of Human Behavior and Social Institutions is an integral part of the National Bureau. It functions under the same corporate rules and procedures as apply to all other areas of research within the National Bureau of Economic Research. Victor R. Fuchs is the Director of the Center. Robert T. Michael, an NBER Assistant Vice President, is the Assistant Director of the Center, and is the Acting Director during the current academic year in which Fuchs is on a leave of absence. Gary S. Becker is the Center's Research Policy Advisor.

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

Victor R. Fuchs
Robert T. Michael

</div>

Education and Information and the Distribution of Income

Introduction

This section includes staff progress reports in two program areas, education and information and the distribution of income. The education and information program currently includes three projects: Robert Evenson and Finis Welch's analysis of the role of informational inputs—education, research, and extension—in agricultural productivity; Robert Michael's study of the role of education in household production; and Lewis Solmon and Paul Wachtel's study of effects of school quality on earnings. These studies are supported by grants from the U.S. Office of Education and the National Science Foundation.

During the past year research on income dis-

tributions has continued to be one of the National Bureau's and the Center's major research program areas. A major focus of this research is the lifetime accumulation of human capital —pre-school investments in human capital in children, the accumulation of skills while attending schools, and the subsequent accumulation via on-the-job investments. In addition to these life-cycle studies, research is under way on questions related to race differences in income, the effects of measured ability on earnings, the influence of various socioeconomic factors on earnings and labor supply, the labor force behavior of women, and interactions among these variables that determine or at least "explain" the shapes of earnings distributions. The staff progress reports by Barry Chiswick, John Hause, James Heckman, Arleen Leibowitz, Lee Lillard, Jacob Mincer, Paul Taubman and myself cover most of the Bureau's and Center's work in this area. In addition, James P. Smith's work on family earnings is reported in the population program section.

The income distribution program has been principally funded over the past 2 years by the U.S. Office of Economic Opportunity and the National Science Foundation. The Rockefeller Foundation recently provided the NBER–Center for Economic Analysis of Human Behavior and Social Institutions with support for the two program areas of education and information and income distribution.

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

Finis Welch

</div>

Research, Information, and Agricultural Productivity

This project is now in its third year and is nearing completion. The results are tentatively scheduled to be published in book form with the same title as this progress report. The work focuses mainly on the contributions of "modern" inputs such as research, education, and extension to agricultural productivity.

Much of the empirical analysis is based on the 1964 Census of Agriculture, which contains information on farm operator schooling. In this analysis the estimated aggregate production function consists of two parallel, technically independent production functions, one for crops, the other for livestock. The allocation of labor

between these competing activities is restricted to equality of values of marginal product. The early evidence indicates that earnings differentials associated with schooling *overstate* the contribution of education to labor's product, implying that all the return from schooling is not vested simply in an ability to do more work. Furthermore, the evidence is that both crop and livestock research is pervasive. Research carried out in one state exhibits significant positive effects on the output of states producing similar crops with similar soils and climate.

Our work also includes a theoretical specification of the value of information, with optimal rules for learning from experience when production is subject to uncertain technology. Evenson's analysis reveals a significant international exchange of agricultural research information, and Welch analyzes returns to scale in U.S. agriculture. Evenson has also explored several unique data sets:

1. He has used data on yields of major grain crops by states from 1870–80 and 1890 (a) to estimate differences in average yield levels by major geographic region in the U.S., (b) to appraise differences in the rate of deterioration of yield levels after the settlement of virgin lands, and (c) to correct and partially explain the factor productivity measures for U.S. agriculture during the period from 1889 to 1925. The adjustment only partially altered the pattern of productivity growth. In particular, the stagnancy in productivity growth after 1910 was only partially due to declining fertility.

2. Evenson also has used data from the 1930 and 1940 censuses in an aggregate production function context to study the role of research and extension in increasing productivity and basic data from the 1940–70 period to investigate research-extension-schooling-productivity interactions in U.S. agriculture. In addition to classifying various census data by states, Evenson has compiled a total factor productivity series by states for the 1949–71 period. With these detailed data, and with some richer specifications, updated estimates are developed of the level and time-shape of the effect of research on productivity.

<div align="right">Robert Evenson
Finis Welch</div>

Education and Consumer Behavior

During the past year my NBER book, *The Effect of Education on Efficiency in Consumption* (Occasional Paper 116), was published. An article summarizing some of the results from the book also appeared in the *Journal of Political Economy* (March–April, 1973). The substance of that research has been summarized in previous annual reports.

A revised draft of an essay "On the New Theory of Consumer Behavior," written jointly with Gary Becker, has recently been completed and will be published in the *Swedish Journal of Economics*. In this essay we suggest that the household production function approach to consumer behavior—as developed in Becker's well-known article on the allocation of time (*The Economic Journal,* September 1965)—generates a wide range of cogent testable hypotheses and provides social scientists with tools relevant for understanding a broad spectrum of human behavior. The essay explores applications of an analytical nature (i.e., regarding functional separability and the relative magnitudes of cross-price elasticities) and briefly summarizes several recent empirical applications of this approach. These applications fall into three categories: (1) those that pertain to nonmarket activities, which demand relatively much of the individual's time; (2) those that emphasize the relationships between this production model and the human capital framework; and (3) those that employ the model in studying marital and fertility behavior.

I am now studying differences in households' ability to predict their future purchases of durable goods. For this study I am using the NBER–U.S. Census Bureau's Consumer Anticipation Survey conducted from 1968 through 1970. This data set contains information on the respondent's estimate of the probability of purchasing several specific durable goods over the following 2 years. Re-interviews at 6-month intervals reveal the extent to which expectations were realized and the extent to which the purchases were anticipated. I expect that the predictability and volatility of earnings and other income, changes in family size, and geographical mobility will influence both the purchases and the

accuracy of the household forecasts. Of particular interest is the role of the husband's and wife's level of formal schooling in affecting these aspects of behavior. This project was recently begun and results are too preliminary to report at this time.

Much of my current research is directed toward the influence of schooling levels on household fertility behavior. This research is discussed in the population program section.

Robert T. Michael

Effects of College Quality

This study seeks to identify the characteristics of colleges that affect lifetime incomes and involves the interactions between college quality and an individual's ability, the number of years spent in school, socioeconomic background, and occupation. College-educated members of the NBER–TH data set are the bases of the empirical analysis. I merged information on the college attended with independent information on the quality of the school attended. A list of some of the more interesting, tentative conclusions derived from the study are indicated here.

The quality of the institution of higher education attended has a powerful effect on individual incomes 20 years after the individual left school, but relatively smaller effects on income earned at earlier points on the career profile. From studies of a number of quantifiable dimensions of college quality, it appears that average SAT scores of entering freshmen and average faculty salaries likewise are strong and independent factors in determining the student's subsequent income.

Earnings functions were estimated separately for individuals with 13-15 years of schooling, 16 years of schooling, and 17 or more years of schooling. There appeared to be no statistical difference in the earnings functions for the first two groups, but there was a statistical difference in the functions for individuals with graduate school training. It appears that school quality has a stronger effect on the earnings of individuals who have had graduate school training.

Quality seemed to be more important for individuals in the upper quartile of the I.Q. distribution than for those in the second quartile.

(The data set used included only people in the top half of the national I.Q. distribution.)

The analysis utilizes father's and mother's education and father's occupational status as indices of socioeconomic status. When these factors are included in the earnings function, mother's education appears to be a significant determinant of the individual's 1969 income. For the undergraduate students, income was also positively related to the socioeconomic status of the father's occupation.

Lewis Solmon

Quality of Schools Attended

An exploratory paper by Solmon and Wachtel, "The Effects on Income of Type of College Attended," which was summarized in last year's *Annual Report,* has been completely revised and rewritten. In it, estimates of a human capital earnings function are used to examine the effect of the type of college attended. The scheme developed by the Carnegie Commission is used to classify colleges by type. A variety of measures of college quality show that there are systematic differences in college types. And there are statistically significant differences in the predicted earnings of graduates from the various college types, which suggests that college type and quality are important determinants of the returns from education. The study also examines the effects of ability and socioeconomic class on the choice of college and on the earnings effect of the type of college attended.

I have analyzed the returns from investments in higher education using specific cost data for each college attended by the respondents. The paper, entitled "The Return to Investments in Higher Education Revisited," will be included in the forthcoming Carnegie Commission on Higher Education–NBER volume of essays, *Education, Income, and Human Behavior,* edited by F. Thomas Juster. My results indicate that previous estimates of the rate of return that have ignored inter-school cost variations are biased. The results underline the importance of differences in investment costs per year of college and show that the returns from direct and indirect components of investment costs are different. The paper also examines the variation

in rates of return between ability and socioeconomic class. Finally, students with a higher earning potential invest in more expensive (higher quality) schooling as well as more years of schooling.

Additional work along these lines, currently underway, includes an examination of differences in investment costs and rates of return of respondents who attended public and private institutions. An offshoot of this work will involve a re-examination of earlier studies of the interaction between schooling and ability. Previous Bureau work on the returns from education by Hause and by Taubman and Wales have reached opposite conclusions concerning the importance of this interaction.

My analysis of the high school quality data discussed in last year's report has been underway since last fall, when the data became available. Preliminary analysis suggests that the relationship between school quality measures and post-school achievement tests scores may be as strong as the relationship between quality and earnings. I am also estimating models of school quality, achievement scores, years of schooling, and earnings.

The use of the school quality data has posed some problem because the unit of observation for the quality data is a school district. The analysis is being restricted to students who grew up in rural areas and small cities in which the intra-district variation in school quality is likely to be relatively small. Earnings functions for this sample have yielded some promising results. Student-teacher ratios, length of school term, and expenditures per student all have significant effects on earnings at the 10 per cent level. The Beta coefficients of these school quality measures are as large as the Beta coefficients on ability in regressions on the log of income.

Information on the quality of individual high schools has been obtained from the National Academy of Sciences. The data is being merged with the NBER-TH data tape and should be available for analysis shortly.

<div align="right">Paul Wachtel</div>

Schooling, Work Experience, and Earnings

The NBER review of my monograph, *Schooling,* *Experience, and Earnings,* is now completed, and the manuscript is being prepared for press. In this work, described in earlier annual reports, I applied human capital theory to construct an econometric function that relates aspects of labor quality and of work input to the distribution of earnings. More than half the inequality of earnings revealed in the 1960 U.S. Census among white, non-farm, non-student males was explained by a function that related annual earnings merely to reported years of schooling, estimated years of work experience, and weeks worked during the year. I have devoted the past months to preparatory efforts aimed at broadening the earnings function by including additional measures of accumulated (or inherited) labor capacity, better information on the continuity and variety of training and experience within and outside the labor market, and explicit analyses of demand and supply factors determining the amount of time spent in the labor market annually and for longer periods.

Empirically, these efforts take the form of replicating progressively richer earnings functions on several bodies of data. The 1/100 census sample for 1970 is the cross-section of considerable current interest, but the central, long-run focus is on the utilization of longitudinal, individual income history data. I have started on an analysis of four such bodies of data: the NBER-TH sample, the Eckland sample, the National Longitudinal Surveys (NLS), and the Coleman-Rossi sample. Each of these contains individual income histories and a variety of information on family background and other characteristics.

An example of the use of work experience histories is the analysis of human capital investment and wages of women, based on the NLS data. Preliminary findings are described in a paper, "Family Investments in Human Capital: Earnings of Women," co-authored with Solomon Polachek and presented at the June 1973 population conference sponsored by the NBER and the Population Council.

I plan to use these data sets to study not only life-time income dynamics, but also the parental transmission of human capital via genetic and cultural inheritance as well as by direct invest-

ments in children. With conceptual work and data processing in their initial stages, it is too early to report any findings.

I am also currently updating a joint study with Hashimoto on employment and unemployment effects of minimum wages on demographic groups in the labor force.

A paper on "Youth, Education, and Work" appeared in the *National Bureau Report Supplement* for January 1973. A paper on "Determining the Size of Hidden Unemployment" appeared in the March issue of the *Monthly Labor Review,* published by the U.S. Department of Labor.

<div align="right">Jacob Mincer</div>

Family Investments in Human Capital

My research concerns the investments made in human capital before formal schooling begins. My work during the preceding year has focused on two questions: (1) What is the return on these investments in terms of measured ability, amount of schooling achieved, and earnings at later ages? (2) Does the size of these investments vary in a systematic way with the income and education of the parents?

In order to analyze the first question, we needed a source of data with information on earnings, schooling, and home investments. We located such a data set, the Terman sample of the gifted, which contains a 40-year history on 1,500 individuals who at age 11 had I.Q.'s above 140. During the past year we have spent considerable time decoding this data and preparing it for regression analysis. This phase of the work is now complete and Susan Crayne and I have prepared a paper "Decoding a 9-Track Column Binary Tape," which describes the methods used.

Using this data, I have estimated a recursive model of human capital acquisition and earnings for males. The results indicate that even within this very high ability sample, home investment variables (education of mother, time spent in home instruction, birth order) were positively and significantly related to measured I.Q. Education attained by ages 29 and 39 in this high I.Q. sample depended on both ability and home investments, whereas earnings at

ages 29, 39, and 49 did not depend on either factor. Earnings were, however, strongly related to education and experience at the three ages. Although it is difficult to extrapolate these results to the general population, it appears that in this high I.Q. sample, home investments are important in generating ability and that ability and family variables affect educational attainment, but that these variables affect earnings through the schooling variables, not directly. These results have been summarized in a paper entitled "Home Investments in Children," which was presented at the population conference sponsored jointly in June 1973 by the NBER and the Population Council.

Recently I have begun to perform a similar analysis for the females in the sample. The model will then be tested on the children of the original sample members. That extension will permit me to evaluate the relative importance of genetic and environmental factors.

Work relating to the second question, on the determinants of the quantity of home investments, has included the revision of my paper, "Education and the Allocation of Women's Time." I have also begun to extend my study of the demand for inputs to investment in children to a sample that covers disadvantaged children in Los Angeles, California, and Winston-Salem, North Carolina.

<div align="right">Arleen S. Leibowitz</div>

Economic Decision-Making in a Life-Cycle Context

The authors have been conducting separate research projects in the general area of economic decision-making over the life cycle. Because of the interrelated nature of these projects, we now plan to integrate our three works into a single volume dealing with some aspects of life-cycle decision-making. The basic modeling and initial investigations are complete and are included in the authors' respective dissertations. We are in the process of updating or revising our work, and expect to finish this project by September 1973.

The volume is expected to contain separate essays by the three of us. The first essay, by James Smith, focuses on family decisions on

labor supply over the life cycle. In this paper, Smith develops a model that shows that the life-cycle time allocation of family members is determined by the life-cycle wage patterns of *all* family members, the rate of interest and time preference, and any changes over the life cycle in the efficiency of nonmarket uses of time. Smith devotes special emphasis and attention to the importance of the family context for economic decisions. The model investigates two related questions. First, for each family member, how is the available stock of time distributed between market and nonmarket activities? Second, within the family unit, what potential exists for substituting the time of one member for that of another?

The model is tested by comparing its predictions with the life-cycle patterns of household and working time for married men and women based on the 1967 SEO data and the 1960 U.S. Census. Separate profiles were generated for married men and women, both blacks and whites, and for whites by three education levels. A variety of definitions of labor supply were used—annual hours, weekly hours, weeks worked, and yearly and weekly labor force participation rates. On the whole, most of the characteristics of those profiles are consistent with the implications of the family life-cycle model.

Using techniques suggested by Ghez, the model is also tested by running regressions with the variables defined as the mean value at each age. Regressions for male and female home time are reported separately; and as predicted by the model for both groups, a significantly negative own wage coefficient is found. There is also evidence that an increase in the wage of one spouse has a positive effect on the home time of the other.

The second essay, by James Heckman, deals with a variety of decisions over the life cycle. In this essay, he blends several aspects of his unpublished research into a model of life-cycle labor supply, consumption, and asset formation. The model includes the effect of two different types of wage formation behavior: a model in which extra work effort in one period raises future wages, and a model in which oc-

cupations with different training content are selected over the life cycle.

In the first section of the essay, Heckman develops and summarizes theoretical models. In particular, he summarizes recent work by Becker and Ghez, Oniki, Rosen, Sheshinski, and Stafford and focuses primarily on contrasting empirical implications and on similarities among predictions. He explicitly considers the effect of capital market restrictions on work effort, consumption, and asset formation.

In the second section Heckman sets forth an empirical estimate of the theoretical models. Essentially, he bases his methodology on utilizing a cross-sectional average profile over consumers as an estimate of their life-cycle path. His work estimates optimal control paths in terms of the underlying parameters of the utility function, human capital production function, rate of time preference, rate of interest, and the rate of depreciation of human capital. He utilizes these estimates to develop a series of "true" wage rates over the life cycle and to estimate the effects of independent (or exogenous) changes in wages and earnings on work effort, consumption, asset formation, and the investment in human capital.

The final essay, "An Explicit Solution to the Human Capital Life Cycle of Earnings Model and Its Application to Earnings Distributions," is the work of Lee A. Lillard. The plan of his research involves obtaining implications from an explicit solution to the human capital, life-cycle earnings model for age-earnings profiles and investment behavior over the life cycle and for earnings distributions. First, Lillard presents the life-cycle model in the form in which it is used for this research, resulting in an explicit functional form for earnings. He considers labor force participation over the life cycle in the context of allocating one's human capital between the labor market and investment in new human capital, abstracting from the work-leisure choice. These decisions affect earnings. Lillard emphasizes that the earnings profile and length of full-time schooling are determined simultaneously.

Next, Lillard describes how the joint distribution of a population with respect to age, school-

ing, and ability is translated into earnings distribution through the earnings function. He estimates the earnings function in simplified form as a function of age, schooling, and ability, and their interaction using the NBER–TH data and the IRSS–Eckland data. The IRSS–Eckland data is a national sample of high school sophomore males in 1955 who were given achievement tests that year and answered a follow-up survey in 1970.

Lillard then uses the estimated earnings function to derive earnings distributions. He utilizes the distribution by age and schooling of the population of employed males between the ages of 16 and 44 reported by the 1960 Census of Population and the distribution by ability of the Eckland sample to predict the distribution of earnings for the overall population and various age, schooling, and ability groups. The resulting distributions display the usual characteristics associated with earnings distributions and are not unlike the actual distributions reported in the 1960 Census of Population.

James Heckman
Lee A. Lillard
James P. Smith

Ability, Individual Investment in Human Capital, and Earnings over the Life Cycle

Since arriving at the National Bureau in the summer of 1972, I have completed and defended my doctoral thesis at North Carolina State University. The dissertation presents a formal model of the pattern of earnings over the life cycle. The substance of this research is described briefly in the preceding report, "Economic Decision-making in a Life-Cycle Context." The model explores the factors that influence the amount of resources individuals spend in full-time schooling, in learning outside of school, and in earning money.

The general model accommodates many special cases, and I am now exploring some of these, including (1) alternative specifications of the consumption and investment loan markets and conditions under which consumption and investment decisions can be separated; (2) a set of direct educational inputs in the production function for human capital rather than a

single aggregate input; and (3) generalization of the framework to include several kinds of human capital that are useful in various jobs (i.e., heterogeneous human capital).

I am continuing to estimate the earnings function using the IRSS–Eckland data and the National Bureau's NBER–TH data. These data sets permit me to study (1) how the number of weeks worked affects earnings, (2) the extent to which one's general level of health affects production efficiency, and (3) possible sources of differences in the variance of the estimating equations' error terms that undermine statistical accuracy in estimating the coefficients (i.e., heteroscedasticity). An important innovation involves considering the possibility that measured ability indices are an ordinal ranking of the theoretical notion of "ability."

Once I have an improved estimate of the earnings function, I will use it to derive predicted earnings distributions. I use the earnings function to translate the joint density of age, schooling, and ability of a population into earnings densities. Then I compare earnings distributions with the actual distributions and consider several measures of "goodness-of-fit." If I am able to generate from my equations a predicted distribution of earnings for specific groups in the U.S. that reasonably approximates the actual distribution of earnings, we will be far more confident that our models focus on the relevant set of explanatory variables.

Lee A. Lillard

Racial Discrimination in the Labor Market— A Test of Alternative Hypotheses

Writers on the subject have identified employees, employers, consumers, and the government as causing discrimination. Little empirical work has been done, however, to test these separate hypotheses. This study, which is an outgrowth of my work on income distribution, tests empirically racial discrimination among white and nonwhite male workers using states as the units of observation.

Theoretically, white employee discrimination creates a component in the inequality of weekly income within skill levels that is a rising function of the percentage of the male labor force that is

nonwhite. The "job-rationing" hypothesis, under which nonwhites receive the lowest-paying jobs within skill groups, predicts a negative partial correlation between the percentage of nonwhite and white income inequality. I also have examined the distribution of labor market income of nonwhites within skill and weeks-worked categories. The hypothesis that nonwhite employees discriminate against working with whites and the job-rationing hypothesis predict a positive partial relation between the percentage of nonwhites in the particular state and the inequality of nonwhite labor market incomes. Other discrimination hypotheses offer no basis for predicting the effect of the percentage of nonwhites on the inequality of weekly labor-market incomes within white or nonwhite skill categories.

Holding constant the distributions of schooling, age, and weeks worked, and the rate of return from schooling, I have found that the partial effect of the percentage of nonwhites on the inequality of income among whites is positive and significant. For nonwhite income inequality, the partial effect of the percentage of nonwhites is not significant. Thus, there is empirical support for the white-employee discrimination hypothesis but not for the nonwhite-employee discrimination or the job-rationing hypotheses. White income inequality is increased by more than 3 per cent because of white worker discrimination.

An article reporting the results of this project has been accepted for publication by the *Journal of Political Economy* (November 1973).

Barry R. Chiswick

Relationships between Income and Schooling

Following completion of the paper, "Black-White Differences in the Return to Schooling" (described in the last *Annual Report*), I completed another, "Racial Discrimination in Education," which delves more deeply into quality-related aspects of differences between schools attended by blacks and whites. The income data show returns from schooling such that schooling is more valuable to younger, more recent entrants into the workforce. These effects appear to be considerably stronger for blacks than whites. Blacks schooled in the 1920s and 1930s received much lower returns from schooling than did whites, but for persons entering the labor force since 1955, the dollar values of income returns to blacks are only slightly less than for whites. If the contribution of schooling is measured as a percentage of income, returns appear higher for blacks than for whites. Because these trends have existed (at least) since the 1930s and because there are cohort effects for whites as well as blacks, I suspect that a greater part of the change is rooted in improved relative quality of schools attended by blacks rather than in declining market discrimination. Certainly all the school system data suggest relative improvement in black schools since the first decade of this century.

To pursue this question further, I am beginning an analysis of the returns from schooling exhibited in the 1-in-100 samples of the 1960 and 1970 censuses. The main objective is to disentangle cohort effects from whatever effects may have resulted from efforts of the federal government to reduce market discrimination.

In addition to this emphasis on racial differences in returns from schooling, I have completed a survey paper, "Relationships between Income and Schooling." Following a brief description of the published research on rates of return, and so on, I explored the linkages between measured ability or achievement and returns from schooling in some detail. The crux of my argument is that measures of ability are very crude indices of whatever it is that the market buys, so that observations that schools have little effect on measured achievement and that achievement adds little to income should not be considered as indictments of the failure of schools to produce marketable skills.

Finis Welch

Income Inequality: Regional Analyses within a Human Capital Framework

I am currently completing my manuscript on an analysis of the distribution of labor income across and within regions. The book encom-

passes much of the research I have undertaken on this topic over the last few years. My analysis emphasizes the effect of investment in human capital on several characteristics of the personal distribution of income. Part A of the book explains in non-technical terms the human capital model and its relation to the distribution of income. This section is written for laymen and indicates the contribution the general human capital model can make to an understanding of the income distribution. The section also summarizes the results of the more technical analysis in the remainder of the book.

Part B focuses on investments in formal schooling. I develop a model that relates labor market income to investments in schooling and the rate of return. Assuming no variations in the rate of return, this model relates income inequality to the inequality of schooling and the level of the rate of return. If individual variations in the rate of return from schooling are permitted, the level of schooling and the variance in the rate of return enter the analysis. I develop here and discuss in detail the regression estimate of the rate of return from schooling.

I use data on adult males in the United States and Canada, and in several other countries, and compute the effects of schooling on differences in the income of individuals within a region and differences in relative inequality of income across regions. The analysis shows that schooling is an important variable. For the United States, schooling explains from 17 to 51 per cent of individual differences in income of adult males in each state. Interstate differences in the rate of return from schooling and the inequality of schooling explain 60 per cent of state differences in inequality of income. The higher income inequality in the South is caused by the higher inequality in schooling and the higher rate of return from schooling in that area. The rate of return from schooling is higher in the South because of the national labor market for highly educated workers and the preponderance of local labor markets in the South for those with little schooling. The difference in the extent of the relevant labor market is related to the greater profitability of migration and the geographically extensive job seeking by individuals who have

more education. As the schooling model predicts, the strong negative simple correlation between the level of schooling and the inequality of income disappears if the rate of return and inequality of schooling are held constant.

The interregional analyses for Canada and for several other countries provide additional support for the hypothesis that income inequality increases as the rate of return from schooling and the inequality of schooling increase. The model also provides a framework for interpreting the income distribution effects of historical events (mass migration into Israel), institutional differences (Great Britain versus the United States), and economic growth.

Part C uses Mincer's extension of the human capital earnings function, which adds post-school training and employment during the year to the schooling model.[1] By computing variances from the earnings function, the level and inequality of income are related to the distribution of years of schooling, years of experience, weeks worked during the year, and the rate of return from schooling. The effect of racial discrimination on the distribution of income is also explicitly incorporated into the model.

Analyses for all white and nonwhite males in the United States and for nonfarm males in Canada indicate that the independent variables can explain (adjusted R^2) 85 to 90 per cent of the interstate variations in relative income (or earnings) inequality. The most important explanatory variable is the rate of return from schooling, followed by the relative inequality of weeks worked, the inequality of age, and the inequality of schooling.

Differences in the level of income are analyzed by relating the average level of the log of income (i.e., the log of the geometric mean) to the levels of schooling, post-school experience, and weeks worked. For white males, schooling is by far the most important variable in explaining state differences in the level of income and earnings. For nonwhite males, both schooling and weeks worked are very significant explanatory variables.

---

[1] See Jacob Mincer, *Schooling, Experience, and Earnings,* NBER, forthcoming.

These studies demonstrate that the income distribution can be related to an investment in the human capital model and that the predictions of the model are consistent with regional data from several countries and from inter-country data. In addition, the model provides a framework for understanding the income distribution effects of historical events, institutional arrangements, and economic growth.

Barry R. Chiswick

Distribution of Earnings

During the past year, I have been studying three aspects of the distribution of earnings in the NBER–TH sample. First, expanding on the work of T. Wales and myself, as published in the January 1973 issue of the *Journal of Political Economy,* I have incorporated several new and highly significant variables into the analysis. The most important of these are business assets of the self-employed, a measure of risk preference, religion, additional measures of socioeconomic background of the respondents and of his spouse's family, work experience, hours, and health-related measures. In addition, I have begun to estimate equations for first-job terminal earnings as collected in 1955 by Thorndike and Hagen. Some interesting findings in the equations, which contain all the above variables as well as education, ability, age, and others, are that Jews who were not self-employed earned from 30 to 40 per cent more than Protestants, who earned 5 to 10 per cent less than Catholics and others in 1969, 1955, and in the year in which earnings were initially reported. Also, those who prefer not to be self-employed (if chances of financial success are about equal) earned 15 to 25 per cent less than those who prefer self-employment—even after including a dummy variable for being self-employed and the amount of business assets. The equations also indicate that several dimensions of socio-economic status are related to earnings. In an equation for the amount of business assets held by the self-employed, the earnings and risk preference are significant but mental ability and family background are not.

Without introducing detail on occupation, the earnings equation for 1969, the only period for which self-employment and other data were collected, has an R^2 of nearly .30. However, the residuals from the 1969 and 1955 equation have an R^2 of .16, implying that there are some other common, non-measured variables whose inclusion would raise the R^2 of 1969 earnings to over .40.

The second substantive part of my research deals with the determinants of the shape of the distribution. I have been calculating the variance, skewness, and peakedness (i.e., kurtosis) in the whole sample and by education and ability level. I also calculated the residuals from the above earnings equations to determine the contribution of various measured variables to the shape of the distribution. Much of this analysis remains to be done, but it appears that the earnings distribution departs less from the normal curve in 1969 than in 1955. The partition by education and ability suggests that in 1969 skewness increases with ability and with education, but that the opposite is true in 1955. One striking finding is that the skewness (asymmetry) and kurtosis measures (after dividing by the standard deviation raised to the appropriate power) do not change much if education, ability, family background, risk preference, self-employment variables, and other selected variables are held constant.

The third major part of the study has been concerned with the stability of the earnings distribution and people's position within it over time. Between 1955 and 1969, people tended to regress somewhat toward the mean of the income distribution, but most people's position changed by no more than 10 percentile points. The average growth rate in earnings was smallest for those in the top 10 per cent in the 1955 distribution and highest for those in the bottom 10 per cent. Between these years, the average growth rate was invariant to 1955 earnings level, although the variance about the mean is greater for those with high 1955 earnings. In my "Annual and Lifetime Earnings" paper I present these growth rate distributions and use them to test various theories of the distribution of earnings. The distributions are not in accord with stochastic theories (i.e., theories that emphasize

randomness) as normally proposed nor, in my opinion, with Mincer's on-the-job training model. They do not contradict a weakly specified version of a model that emphasizes sorting out workers by observing performance on the job.

I also have completed several technical studies on the reliability of the NBER–TH data.

<div align="right">Paul J. Taubman</div>

The Covariance Structure of Earnings Profiles

Developing and testing hypotheses about the evolution of personal earnings over time is a central topic in human capital research. I have completed a first draft of a study that explores how covariance information from longitudinal data on individual earnings may be used to evaluate the relative importance of on-the-job training, random walk development, and transitory earnings fluctuations in describing individual earnings profiles. If differences in on-the-job training can be approximated by a distribution of slopes of earnings profiles over some range of employment experience, one can attempt to describe a person's earnings over time by the equation $x_t = m + tw + u_t + v_t$, in which x_t is earnings in year t, and m, w, u_t, and v_t are random variables. In the equation, m represents the distribution of earnings differences owing to ability at Jacob Mincer's "crossover period," w is a distribution of earnings profile slopes that corresponds to different amounts of on-the-job training opportunities, u_t is the transitory earnings variation, and v_t is accumulated (permanent) effect of random shocks. This model is fruitful for devising tests about the relative strength of the random components. I have made some preliminary calculations with Låginkomstutredningen data on Swedish earnings, mentioned in my report last year, and from the American sample collected by D. C. Rogers. I expect to interpret additional calculations with a large Swedish sample in this framework later this year.

<div align="right">John C. Hause</div>

Empirical Applications of Labor Supply and Demand

This year I have divided my time among three main projects. The first is an investigation of the effect of tied work offers on labor supply. Many welfare reform proposals require that cash grants be made only if an individual works a minimum number of hours. To predict the effect of such programs requires information about the individual's work preferences. To acquire such information, I have estimated indifference surfaces between goods and leisure and hence am able to estimate labor force participation functions and hours of work functions from a common set of parameters. The slope of these surfaces at zero hours of work yields estimates of the wages at which individuals would accept a job. With certain assumptions about preferences over time, the method can be generalized to a life-cycle model. I have used one version of the model to estimate the effect of alternative child care programs on women's work efforts. These estimates were presented at the June 1973 NBER–Population Council conference on population. The results suggest that there is scope for Pareto optimal redistribution of welfare payments and time: By making tied grants, it is possible to reduce welfare payments, raise work effort, and keep individuals at the same level of well-being.

I developed new statistical methods to estimate the parameters of this model. These methods are reported in a separate paper, "Shadow Prices, Market Wages, and Labor Supply," which will appear in a forthcoming issue of Econometrica. In this paper I show that traditional procedures for estimating labor supply and wage functions on subsamples of working women lead to biased parameter estimates. I develop a maximum likelihood technique that combines observations on working women with observations on non-working women to yield consistent estimates of wage functions and labor supply functions.

Another of my topics of research is the specification of the human capital earnings function. In a joint paper with Solomon Polachek, we used maximum likelihood methods to test the best functional form for the schooling-earn-

ings relationship. The best *simple* specification turned out to be quite close to the functional form proposed on independent grounds by Becker, Chiswick, and Mincer. In a related piece of research, currently underway with Barry Chiswick, we are using a random coefficients model to estimate the variance of the rate of return from schooling. This estimate can be used to explain how much of the observed variance in earnings is due to variance in rates of return from schooling.

My third topic of research is the effect of government programs on behavior. In joint research with Orley Ashenfelter, we use a new body of data to investigate the effect of government contract compliance on racial integration in segregated firms and the upward mobility of black males within all firms. This research is currently being extended to females of both races. Preliminary results on black males suggest that integration effects are quite strong, but upward mobility effects are much weaker. A related research problem is the effect of compulsory schooling laws on school enrollment rates. Using new statistical methods that provide for dummy endogenous variables, I am testing the Stigler hypothesis that laws reflect tastes and do not have an independent effect on behavior. At the time of this writing, no empirical results are available.

James Heckman

Law and Economics

Introduction

During the past year several studies have been completed. Two have already been described in detail in previous annual reports. They are an analysis of the bail system by William M. Landes (which has been published in the *Journal of Legal Studies,* January 1973), and a theoretical and empirical analysis by Isaac Ehrlich of the deterrent effect of law enforcement on crime rates in the United States, using cross-sectional data (which appeared in the *Journal of Political Economy,* June 1973). Richard Posner has completed papers, described in detail below, on the behavior of administrative agencies (which has been published in the *Journal of Legal Studies,*

June 1972) and on the economic consequences of strict liability (which has been published in the *Journal of Legal Studies,* January 1973). We are also in the process of bringing out a collection of essays on law enforcement edited by Gary Becker and William Landes. The volume will include essays completed in the law and economics program by Becker, Ehrlich, Landes and Posner, and an essay by George Stigler, who has recently joined the law and economics program.

The research activity of the past year, which is described more fully in the individual reports below, includes the following: a study by Becker and Stigler on the incentives to enforce laws; Ehrlich's empirical analysis of the time trend of crime and the deterrent effect of capital punishment; Landes' work on criminal court behavior; Posner's study of optimal rules of legal procedure; Reder's analysis of the theory of contracts; Stigler's analysis of the sources of economic legislation; and Bartel's study of the demand for private protection. The law and economics program is currently being supported by a grant from the National Science Foundation.

William M. Landes

Law Enforcement, Fidelity, Corruption, and Compensation of Enforcers

We have completed a draft of a paper on the general problem of enforcing laws and rules, which includes the issue of achieving fidelity in the performance of employees.

We view enforcement and disobedience, or infidelity, as services that are provided according to rational calculations of the parties to the law or contract. No society can expect (or afford) full compliance with any law, and no violator can expect on average to disobey without cost a law whose enforcement is desired. We examine the effects of types of people, methods of compensation, frequency of violation, and the presence of victims on the rate of violation and the costs of enforcing a law.

Next, we study the effects of bribes on the cost of enforcement and show that under certain conditions bribery does not affect the level of enforcement or the costs of violation. We pro-

pose a system of compensation that reduces the willingness of enforcement agents to take bribes without increasing the costs to the enforcing body.

The possibility of relying on private enforcement of public laws deserves serious consideration. Indeed, the triple-damage penalties received by private parties have become the main sanction of the Sherman Antitrust Act. Well-known optimality conditions of free markets are shown to apply also in enforcement activities.

The paper is presently being revised for publication.

Gary S. Becker
George J. Stigler

The Time Trend of Crime

This research aims at identifying the basic factors underlying time trends in various crime statistics; establishing the relevant causal relationships; and studying the interactions over time among the rate of criminal activity, losses to victims of crime, public law enforcement through police and courts, and private self-protection by individuals and firms. The analytical framework builds on the recent papers by Becker, Ehrlich, and Stigler. (See G. Becker, "Crime and Punishment: An Economic Approach," *Journal of Political Economy,* March–April 1968; I. Ehrlich, "Participation in Illegitimate Activities—A Theoretical and Empirical Investigation," *Journal of Political Economy,* May–June 1973; and G. Stigler, "The Optimum Enforcemnt of Laws," *Journal of Political Economy,* May–June 1970.)

The criminal sector of the economy is being analyzed within a framework of interacting supply and demand forces—the supply of criminal offenses on the one hand and the negative demand for crime by potential victims on the other. The supply relations can be expressed by a set of supply-of-offenses functions for specific crimes as well as for all offenses taken together. Demand functions are derived for law enforcement activity by police and courts, and for self-protection on the part of individuals and firms. The interaction between supply and demand is analyzed by (1) production functions of law enforcement activity, relating the probabili-

ties of apprehending and convicting offenders to public expenditures on law enforcement; and by (2) criminal payoff functions for specific crimes against property, relating the average values of property stolen per offense to the specific crime rate and to private and public expenditures on self-protection.

The empirical investigation aims at identifying and estimating those structural functions for which complete time series data are available. The theoretical expectations concerning the various interactions between the supply and demand relations outlined above indicate the necessity to employ simultaneous techniques for estimating the structural equations. I am investigating several specific topics.

1. I am studying the validity of the trend in specific crime rates as exhibited by F.B.I. data and examining them in relation to changes in (a) the efficiency of the F.B.I. reporting systems, (b) victim's incentives to report crimes, and (c) definitions of specific crime categories.

2. I am estimating supply-of-offenses functions for specific crimes against property and crimes against persons and studying the interdependence among such crimes over time.

3. I am estimating and comparing the deterrent effect of law enforcement activity by police and courts separately.

4. I am investigating the effectiveness of law enforcement agencies in apprehending and convicting offenders and in reducing crime as compared to the effectiveness of other regulatory bodies in the economy in suppressing and controlling noncriminal violations of law.

5. I am investigating the determinants of trends in criminal activities of specific population groups, particularly of females, males, and nonwhites throughout the period 1933–69 and especially since World War II.

Isaac Ehrlich

The Deterrent Effect of Capital Punishment

The debate over the legitimacy or propriety of the death penalty may be almost as old as the death penalty itself and, in view of the trend toward its abolition, perhaps as outdated. One outstanding issue has become the subject of increased investigation in recent years; namely,

the deterrent effect of capital punishment. This study is devoted to the examination of this issue in both theory and in practice.

Recent studies by Becker, Ehrlich, and Stigler—cited in my accompanying report, "The Time Trend of Crime"—use economic theory to present both analytical considerations and empirical evidence in support of the proposition that offenders respond to incentives (i.e., that punishment and law enforcement deter the commission of specific crimes). Opponents of capital punishment have not questioned the validity of the deterrent effect of punishment in general. What has been questioned by these scholars is the existence of a *specific* deterrent effect of the death penalty over and above its most common practical alternative—life imprisonment. Some previous empirical investigations have concluded that the existence of the death penalty does not influence homicide death rates. This conclusion has been based largely on a simple correlation between homicide rates in contiguous retentionist and abolitionist states in the United States (see T. Sellin, "Homicide in Rententionist and Abolitionist States," in T. Sellin, ed., *Capital Punishment,* New York, Harper & Row, 1967). Recent econometric analysis of crime and law enforcement indicates that simultaneous equation techniques are the correct method for determining a causal relationship between the frequency of actual imposition of the death penalty and homicide death rates. We have attempted to explain the rates of change in murder and nonnegligent manslaughter in the United States between 1933 and 1968 by the rates of change in estimated probabilities of being arrested, convicted, and executed for murder, as well as in age composition and in labor force participation rates. Preliminary results of regressions indicate a significant negative association between rates of change in the overall probability of execution and homicide death rates in the United States.

Isaac Ehrlich

Criminal Court Procedure—
An Economic Analysis

The purpose of this study is to quantify the interrelationships among criminal court procedure, socioeconomic characteristics of defendants, and the outcome of court proceedings. The theoretical framework for the study is based on my two recent papers on the courts and on the bail system (see W. Landes, "An Economic Analysis of the Courts," *Journal of Law and Economics,* April 1971; and "The Bail System: An Economic Approach," *Journal of Legal Studies,* January 1973). This study will attempt to test several hypotheses concerning the determination of bail; the harm done by defendants released on bail; and the effects of pretrial status and other variables on plea bargaining, sentencing, and other methods of disposition. The study utilizes a unique and rich source of data: a random sample of nearly 1,000 defendants in criminal court in New York City in 1971 that contains detailed information on the defendant's prior criminal record, his socioeconomic characteristics, the current charge against him, the various court proceedings involving him, and the outcome of his case.

My preliminary analysis has focused on the question of the consistency of actual bail practices, with the rules derived from an optimal bail system. The study shows that various measures of the extent and severity of the defendant's prior record and the seriousness of the current charge against the defendant, but not the type of crime, are significant predictors of the probability of his committing crimes while released on bail. Two common hypotheses on the social function of bail are also tested. The first asserts that the primary function of a bail system is to ensure the defendant's appearance at trial; the second emphasizes the use of bail as a means of preventing future crimes by defendants. Our empirical analysis reveals that the second hypothesis is more consistent with actual behavior: The factors that lead to the setting of higher bail bonds (which in turn are shown to reduce the likelihood of pretrial release) are the same factors that predict the likelihood of a person's committing crimes during his period of pretrial liberty but have little to do with explaining the high disappearance rate (around 30 per cent) of those released on bail.

I plan further empirical analysis of this data along several lines: (1) an analysis of the ef-

fects of pretrial status on the outcome of a case (the hypothesis to be investigated is that pretrial detention adversely affects the outcome of the defendant's case); (2) an analysis of plea bargaining to determine the causal factors of sentence reductions for defendants who plead guilty; (3) a separate analysis of defendants accused of crimes involving drugs; (4) an attempt to construct simultaneous equations of defendants in criminal court stressing the interactions among various parts of the criminal proceedings. We are also investigating the possibility of obtaining other sources of data for areas outside New York City.

William M. Landes

Administrative Agencies

A study of the behavior of administrative agencies (discussed in the 1972 *Annual Report)* was completed and published in *The Journal of Legal Studies,* Vol. I (June 1972), p. 305. The first part of the study develops a model that explains the behavior of a rational utility-maximizing administrative agency. The model predicts how such an agency will allocate its resources among different types of cases, how many cases of each type it will pursue, how it will respond to changes in its budget, and when it will settle a case rather than litigate it. I tested the model against some empirical data drawn from the Federal Trade Commission. A principal finding is that a rational utility-maximizing agency will, in the aggregate and under certain plausible assumptions, devote a disproportionate amount of resources to its small cases.

The second part of the study uses the model as the basis for an empirical inquiry into an important issue in administrative procedure: whether combining prosecution and adjudication in the same agency (a common practice) biases the agency's adjudicative determinations. The method of analysis I used to examine this issue involves deriving the implications of the hypothesis and then testing them, using data drawn from the Federal Trade Commission and the National Labor Relations Board. An example of a testable implication is that members of an agency in which the functions of prosecu-

tion and adjudication are combined will be more reluctant to dismiss complaints issued during their tenure as members than to dismiss complaints authorized by their predecessors. My tests of this and other implications of the bias hypothesis indicate that the hypothesis is not supported. The paper closes with a brief discussion of why, despite the apparent absence of bias, Congress decided to separate the functions at the Labor Board.

Richard A. Posner

Liability Rules

During the past year I completed and had published an additional article on accident law ("Strict Liability: A Comment," *The Journal of Legal Studies,* Vol. II, January 1973, p. 205). The paper discusses the economic aspects of strict liability (whereby a person who inflicts an accident is liable for the damage caused regardless of his fault or lack thereof) and compares them with those of negligence liability. In addition, level of accidents, incentives to engage in safety research, litigation costs, and other economic effects of the two systems of accident liability are analyzed. My general analytical conclusion is that strict liability with a defense of contributory negligence is neither more nor less efficient than negligence (with contributory negligence). The paper also discusses several recent articles advocating greater use of strict liability and concludes that the articles are flawed by their failure to analyze correctly the comparative economic aspects of the two systems of liability.

Richard A. Posner

Legal Procedure and Judicial Administration

This study, which was published in the June 1973 issue of the *Journal of Legal Studies,* analyzes from an economic standpoint rules of procedure and other features of the legal dispute-resolution system. The paper builds on recent National Bureau studies by William M. Landes and by myself on courts and administrative agencies, respectively, but is more than an extension of previous work. That work took for

granted the rules of precedure that provide the framework for legal dispute resolution, whereas the present study uses economic theory to explain the rules and practices that give the system its distinctive structure. My basic approach in the paper is to conceive of the social purpose of legal procedures as being the minimization of the sum of two types of cost: "error costs" (i.e., the social costs generated when a judicial system fails to carry out the allocative or other social functions assigned to it), and "direct costs" (e.g., in lawyers' time) of operating the legal dispute-resolution machinery.

I have examined error costs in detail, particularly in accident cases, the most common type of civil case, as well as those related to the likelihood of convicting an innocent person of a criminal offense. I use the analysis of error costs to explain (among other things) the difference in standards of proof followed in civil and criminal cases. I also discuss important features of administrative procedure, such as the right of judicial review. I also have studied direct costs in detail. The determinants of the rate of out-of-court settlements are also analyzed. Since settlements normally are much cheaper than trials, a higher settlement rate usually results in lower direct costs. I have developed an economic model of the settlement process and have used it to explain the provisions for pretrial "discovery" that now exist in most procedural systems in this country. ("Discovery" is a legal term referring to rules that enable the court and the parties in the dispute to obtain information before the trial on the nature of the defense, the evidence, and so forth.) The model is useful in analyzing the effect on the settlement rate of particular discovery rules, of prejudgment interest, of delay in court, and of a requirement that the losing party reimburse the winning party's attorney and pay witness fees.

Second, I have studied the costs of litigation incurred (when settlement negotiations fail) and suggest an economic reason for the law's tolerance of "collusive" efforts to reduce litigation expenditures. A model that predicts the expenditures of parties to a lawsuit when collusion fails is complicated by the interdependence of the parties' expenditure decisions; I propose and defend a model similar to the Cournot duopoly model. I also discuss nuisance suits, various ways of lowering the cost of litigation, and the interaction between error costs and direct costs. Several concrete examples of this interaction are discussed, including the rules limiting relitigation of the same claim between the same parties and the problem of delay in court. The last part of the study deals with decision by judicial precedent as an economizing feature of judicial decision-making.

I plan further empirical studies to test some of the hypotheses developed in the present study.

Richard A. Posner

A Theory of Contracts

I have completed the first draft of a manuscript, "Conflicts and Contract: A Theory," whose point of departure is the work of Landes and Posner and which explains the relative frequency with which disputes at law are settled out of court. The model, which explains the behavior of parties to a lawsuit, is extended to cover the behavior of other types of contestants as well, including those involved in industrial disputes, wars, and civil disturbances. A preliminary search of available data supports the basic conjectures.

In developing the model, it became apparent that a legal contest bears a deep analogy to a voluntary transaction. Accordingly, I generalized the model so that it applied to voluntary exchange. In this context the model implies the existence of a positive association between price change and transaction volume on organized exchanges, which appears to be consistent with the findings of specialists. The model has further implications for relating uncertainty to transaction volume that should be reflected in the volume of mergers and sales of durable assets. In the case of mergers, the theoretical predictions are strikingly similar to Gort's empirical findings on mergers. I intend to extend the model's applications to the behavior of foreign exchange and gold markets.

Melvin W. Reder

The Sources of Economic Legislation

The central problem under study here is the extent to which the nature and existence of legislation regulating economic behavior can be explained by the self-interest of various groups that benefit or lose from the legislation. In one sense everyone makes frequent use of this hypothesis—for example, in explaining tariffs. But the explanations are usually casual and non-quantitative, and therefore are not fully persuasive.

There are two main difficulties involved in explaining a given economic regulatory policy. The first is to identify the purpose of the policy, which I am prepared to assume coincides with its effects. Until one knows why a law was passed, one cannot identify beneficiaries and losers under that law. The second main problem is to determine the quantitative effectiveness of the law. The same law can have very different effects in different kinds of communities, or under different degrees of enforcement.

These difficulties are fully exemplified yet very incompletely surmounted in the first type of economic legislation under study, the state fair employment practice laws. These anti-discrimination laws were carefully studied by William Landes (see *Journal of Political Economy*, July–August 1968, pp. 507-552) and I have used his findings as the basis of my analysis. Specific groups of workers who we would expect to be the primary gainers and losers from effective anti-discrimination policies are identified and related to various measures of the effectiveness of the laws. It is symptomatic of the complexity of the example that the dates at which states passed such laws are unrelated to the resources devoted to their enforcement in 1959. At most it can be claimed that a modicum of support was found for the self-interest hypothesis.

I am now examining alternative policies whose effects are somewhat easier to estimate, such as those that control entry into a particular field of employment.

<div align="right">George J. Stigler</div>

The Demand for Private Protection

Although it is well known that government ex-penditures for police protection have risen rapidly during the past decade, less well known is the fact that private expenditures for police protection have increased correspondingly during this period. The Rand Corporation estimates that in 1969 private security expenditures totaled $3.3 billion (95 per cent by firms rather than households), which represents a 100 per cent increase (in constant dollars) over private expenditures in 1959 (see J. S. Kakalik and S. Wildhorn, *Private Police in the United States*, Rand Corporation, Santa Monica, December 1971). Although public expenditures have been subjected to investigation, little systematic analysis has been directed at the private sector's allocation of resources to this function. It is the objective of this study to determine what affects private demand for security personnel and equipment.

There are several interesting questions related to this problem, which I intend to answer. For example, how is the increased spending related to business losses from crime? Are public and private expenditures substitutes or complements for each other? Does a firm choose self-protection in place of market insurance or does it use both simultaneously?

The theoretical framework of this study is the "state preference" approach to behavior under uncertainty, in which firms are assumed to maximize their expected utility. Protection expenditures enable the firm to reduce the probability of losses from crime whereas market insurance reduces the size of losses should they occur. The optimal expenditures on protection and insurance can be derived by maximizing expected utility, and the determinants of these expenditures can be analyzed with respect to changes in such factors as public expenditures on law enforcement, the size of the loss from crime, and the probability of a loss.

The primary source of data for analyzing private protection is the Small Business Administration's 1968 survey of crime against business. This survey was designed to measure business losses from various crimes and protection expenditures by individual firms. The sample of firms was selected from corporate and business tax returns for the fiscal years ending between

July 1, 1965, and June 30, 1966, and approximately 2,500 firms were interviewed and included in the final sample. The crime categories covered in the survey were burglary, shoplifting, robbery, vandalism, employee theft, civil disturbances, and bad checks; dollar losses and number of crimes are supplied for each category for the 12-month period prior to July 1968. In addition, each firm reported total expenditures on protective devices; current monthly expenditures for protective services; and information on private guards, other security devices, and insurance. Data are also supplied on characteristics of each firm, such as location, industry, and number and type of employees.

Preliminary regression analysis shows that security expenditures by firms respond positively and significantly to both the size of the loss and the probability of the loss. Moreover, the elasticity of security expenditures with respect to the probability of a loss is greater than the elasticity with respect to the size of the loss. I intend to explore the implications of this result insofar as attitudes toward risk are concerned and will investigate losses from various crime categories, the substitution of real protection variables (e.g., guards) for expenditures, and the firm's response to the discrepancy between expected and actual losses. In addition, I will use the 1940, 1950, 1960, and 1970 censuses of population to analyze the demand for private police protection across states and over time and the business loss figures computed from the Small Business Administration to measure average state losses in the 1970 cross-sectional analysis.

Ann P. Bartel

Economics of Health

Introduction

The research program in the economics of health focuses on the determinants of health, the effects of health on various aspects of consumer behavior, and the cost of medical care. The program is supported primarily by a grant from the National Center for Health Services Research and Development, U.S. Department of Health, Education and Welfare. In January 1973, the program received an additional grant from the Robert Wood Johnson Foundation. This grant will be used for expanded research and training in the economics of health.

Victor Fuchs, the program director, spent the academic year 1972–73 as a Fellow at the Center for Advanced Study in the Behavioral Sciences in Palo Alto, California. Michael Grossman served as the acting program director in his absence. Janice Platt and John Wolfe have joined the program as research assistants, and Christine Wilson is the new program secretary. Emerson Ward, M.D., and Chairman of the Board of Governors of the Mayo Clinic, has joined the multidisciplinary health advisory committee.

Three NBER volumes were published during the past year. These are: *Essays in the Economics of Health and Medical Care,* edited by Victor Fuchs; *Determinants of Expenditures for Physicians' Services in the U.S.,* by Victor Fuchs and Marcia Kramer; and *The Demand for Health: A Theoretical and Empirical Investigation,* by Michael Grossman.

The program was well represented at the International Economic Association Conference on The Economics of Health and Medical Care in Developed Countries in Tokyo in April 1973. Victor Fuchs presented a paper on mortality differentials among developed countries, and Michael Grossman presented a paper, co-authored with Lee Benham of the University of Chicago, on the joint determination of health, hours of work in the market, and wage rates.

The research on surgical workloads has generated a considerable amount of interest and attention. An initial article by Edward Hughes, Victor Fuchs, John Jacoby, and Eugene Lewit appeared in the March 1972 issue of *Surgery.* This article was the subject of editorials in *Surgery* and the *Journal of the American Medical Association* and of a column in the *Wall Street Journal.* Hughes and his associates are now investigating how workloads vary among a variety of practice settings and how surgeons spend their nonsurgical professional time.

The following papers are in press or are available in preliminary form.

1. Barry R. Chiswick, "Hospital Utilization: An Analysis of SMSA Differences in Hospital

Admission Rates, Occupancy Rates and Bed Rates."

2. _____, review article of *The Rising Cost of Hospital Care* by Martin S. Feldstein, *Medical Care,* in press.

3. Victor R. Fuchs, "Some Economic Aspects of Mortality in Developed Countries," International Economic Association Conference on The Economics of Health and Medical Care in Developed Countries.

4. Michael Grossman and Lee Benham, "Health, Hours, and Wages," International Economic Association Conference on The Economics of Health and Medical Care in Developed Countries.

_____ and Elizabeth H. Rand, "Consumer Incentives for Health Services in Chronic Illness," Milbank Memorial Fund Round Table on Consumer Incentives for Health Care.

5. Edward F. X. Hughes, Eugene Lewit, and Elizabeth H. Rand, "Surgical Workloads in One Hospital's General Surgical Residency Program."

Richard J. Radna, Edward F. X. Hughes, Eugene Lewit, and Elizabeth H. Rand, "Determinants of Length of Stay in a Group of Neurosurgical Patients."

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

Health and Consumer Behavior

I am engaged in a number of interrelated studies on the relationship between health and various aspects of consumer behavior, such as labor force participation, investment in schooling and wage determination, and marriage. In these studies, I explore both the effect of health on consumer behavior and the effect of consumer behavior on health. All studies are set in the context of the household production function framework of demand theory. This framework serves as the point of departure for constructing and estimating subsectors of a model in which health, schooling, market productivity, and hours of work in the market are all viewed as endogenous variables (variables determined within the model).

The paper I co-authored with Lee Benham, "Health, Hours, and Wages," and which was presented at the International Economic Association Conference on The Economics of Health and Medical Care in Developed Countries in Tokyo in April 1973, estimates the effects of health on labor supply and wage rates in the context of fully specified structural equations for these two components of earnings. It also examines how the estimated effects of health on labor market behavior are altered when health is made an endogenous variable. In its most complete version, the model consists of three equations: a wage generating function, a supply curve of hours of work in the market, and a health ·function. The health function contains variables that affect both the demand for health and the production of health. Our hypotheses are that an improvement in health should raise market productivity, measured by the wage rate, and should also increase the amount of time available for work in the market. Health itself should respond in a positive fashion to increases in variables such as years of formal schooling completed, physicians per capita in the county of residence, health insurance, and utilization of preventive medical services.

The data source we used to estimate the model is the 1963 National Opinion Research Center health interview survey. Estimates are restricted to white males who were at least 18 years of age in 1963, had completed their formal schooling, and did not reside on farms. Health is measured by combining information on self-evaluation of health status with the number of symptoms reported from a checklist of twenty common symptoms. The actual health index is derived from a principal components analysis of these variables.

The empirical results reveal that an improvement in health raises both market productivity and the amount of time spent in the market. The effect of health on productivity is strengthened when health is made an endogenous variable. Health itself is positively related to schooling, presence of spouse, and physicians per capita in the county of residence, and is negatively related to the amount of time that has elapsed since the last preventive physical examination.

In another study, "The Correlation Between Health and Schooling," I am testing alternative explanations of the positive correlation between

years of schooling and good health. This research seeks answers to the following questions: Does the direction of causality implied by the positive correlation between health and schooling really imply a causal relationship that runs from schooling to health? How much of the observed relationship is due to the omission of relevant "third variables," such as physical and mental ability and parental characteristics? In last year's *Annual Report,* I discussed the results of multiple regression analysis of differences in self-rated health status in 1969 among men in the NBER–TH sample. These results indicated that with a number of potential third variables held constant, schooling had a positive and very significant effect on health. The other independent variables in the regressions included father's schooling, marital status, job satisfaction, mental and physical ability, wife's schooling, difference between actual physical weight and ideal physical weight for a given physical height, and family income.

During the past year, I have investigated the mortality experience of the sample between the initial survey in 1955 and the NBER follow-up in 1969. This investigation is limited to men who completed their formal schooling before 1955 and reported earnings in that year. The findings of the mortality analysis are similar to those of the health status analysis. With monthly earnings in 1955, job satisfaction, and physical and mental ability held constant, schooling has a strong positive effect on the probability of survival. Two difficulties with the mortality analysis are that the men in the sample were only in their thirties in 1955 and that relatively few variables are available for that year. The sample has now reached a point in the life cycle at which death rates in future years should be much higher than in the past. Consequently, one promising area for future research would be to trace the mortality experience of the sample for the next 5 or 10 years. Mortality could then be related to a wide variety of factors that can be measured with the large set of variables in the 1969 data.

Although my results indicate that a true relationship between health and schooling does, in fact, exist, I have not yet established the implied direction of causality. In order to do this, data on past health as well as current health are required. Therefore, I designed some questions on past health that were included in the 1971 resurvey of the NBER–TH sample. Information is now available on self-rated health status during the years that the members of the sample were attending high school and on weeks lost from high school per year, on the average, due to illness. I will use this information to examine the effect of schooling on current health, with past health held constant.

A final study that is at a very preliminary stage involves the interrelationships among health, marriage, and spouse's schooling. It is well-established that age-specific death rates of married men are lower than those of single men. This difference in health by marital status is also reflected in both the NORC and NBER–TH samples. One explanation of this finding is that wives' time and other factors are important in determining husbands' health. Indeed, in the NBER–TH sample, wives' schooling has almost as large an effect on husbands' health as husbands' schooling. An alternative explanation is that there is selective mating in the marriage market. If, as Gary Becker has suggested, persons with complementary characteristics have an incentive to marry, then health of husbands and wives should be positively correlated.

The NBER–TH sample does not contain data on wives' health, but other samples do. In future work, I will relate husbands' health to wives' health and schooling and to husbands' schooling. This should establish whether wives' schooling has an independent effect on husbands' health.

Michael Grossman

Utilization of Surgical Manpower

The surgical manpower project has been investigating the utilization of general surgeons' time in a number of practice settings to answer questions about possible excess capacity in surgery and hidden costs in both the practice of surgery and in the training of surgeons. The first study, "Surgical Workloads in a Community Practice"[1] measured the operative workloads

[1] E. F. X. Hughes, V. R. Fuchs, J. E. Jacoby, and E. M. Lewit, "Surgical Workloads in a Community Practice," *Surgery,* Vol. 71 (1972), pp. 315-327.

of a population of nineteen general surgeons in a community practice in the metropolitan New York area. Workloads had a mean of 4.3 and a median of 3.1 H.E. operations per week, where an H.E. (hernia equivalent) is the standardized unit of measure. A consensus of general surgeons from a number of practice settings felt that a workload of 10 H.E. per week represented an active yet not overwhelming practice. The workloads of these practicing surgeons suggested considerable excess capacity and raised the question of what else they were doing with the rest of their time.

To answer this question, a time-motion study was performed on the same population of surgeons. Of the original nineteen, five had either retired, moved to another community to practice, or were incapacitated by illness. Two new surgeons had subsequently settled in the community. Of these sixteen practicing surgeons, fourteen agreed to be included in the study.

Each surgeon was met at the beginning of his professional day for 2 randomly selected days (for a 6-day working week) in the fall and recorded all his activities for the given day. He was also queried about his professional activities during the preceding evening and asked to keep a log of all his activities for the next week. A surgeon could refuse to be followed on a given day, but could not substitute another day. Two surgeons refused to be observed on the second designated day.

In aggregate, their working week averaged 34.9 hours (Table II-1). Their professional time was almost evenly divided into thirds. They spent 11.7 hours a week in operating and in operating-support activities, such as making hospital rounds and assisting in operations; 11.2 hours in the office; and 12 hours either traveling or in personal or miscellaneous activities. It is interesting that the average surgeon spent approximately half as much time assisting fellow surgeons as he did operating on his own cases, and that the time consumed by traveling during the professional day amounts to almost 5 working weeks over the course of a year. I am still analyzing the determinants of the surgeons' workloads and how they vary with the type of practice each surgeon had. The two studies together suggest that there is excess

TABLE II-1

Average Working Week (Monday through Saturday) for Fourteen General Surgeons in Community Practice

Activity	Mean (in hours)	Percentage
Office	11.16	31.99
Rounds	3.46	9.93
Operating time	8.28	23.75
Chief Surgeon	5.02	14.39
Assisting Surgeon	2.73	7.83
Ambulatory	0.53	1.53
Travel	4.20	12.04
External	3.26	9.33
Internal	0.94	2.71
Personal	4.89	14.01
Meals	2.04	5.86
Other	2.84	8.15
Miscellaneous	2.99	8.28
Laboratory data review	0.45	1.28
Dictation	0.12	0.35
Charting	0.07	0.19
Administration	0.89	2.54
Conversations with other physicians	0.27	0.77
Teaching	0.35	1.01
Other	0.74	2.14
TOTAL	34.88	100.00

capacity in this group of general surgeons and that a measure of the operative workloads alone of such a group gives a fair approximation of the magnitude of their overall workloads.

To evaluate the possible effect of alternative schemes for financing and organizing surgical care on the workloads of surgeons, Richard H. Watkins, M.D. a resident in the Department of Community Medicine of the Mount Sinai School of Medicine, collected data for an analysis of surgical workloads. Watkins performed the field work for a time-motion study of seven general surgeons who comprise the entire general surgical staff of a West Coast pre-paid group practice. This study, still in the most preliminary stages of analysis, indicates that the mean operating workload is approximately 8 H.E.'s per

week. The work week is approximately 50 hours, with less time devoted to assisting in operations and almost none to travel.

A third study will analyze how general surgeons who comprise the full-time general surgical faculty of a major New York City medical school use their time. Working weeks of these surgeons, including evening work at home, approximates 60 hours, but their operating workloads are, in fact, less than those of the surgeons in community practice. The field work for this and the time-motion study on community surgeons was performed by Frederick V. Lorenzo, M.D., now an intern in general surgery at the University of Pittsburgh.

As in past years, Eugene M. Lewit is an active collaborator in these studies, and this year Elizabeth H. Rand has joined the project in a similar capacity.

Edward F. X. Hughes

Hospital and Nursing Home Utilization

In January 1973 I completed a preliminary draft of a manuscript entitled "Hospital Utilization: An Analysis of SMSA Differences in Occupancy Rates, Admission Rates and Bed Rates." The theoretical analysis assumes that in the short run the number of beds per thousand population (the bed rate) is fixed, and the admission rate and occupancy rate are determined simultaneously. In the long-run model, the bed rate and the admission rate also are determined simultaneously.

A model for the randomness of hospital admissions hypothesizes that occupation rates are higher in larger cities, in cities with higher admission rates, and in cities with fewer hospitals. These hypotheses are confirmed by the data. In addition, occupancy rates are higher in SMSA's (Standard Metropolitan Statistical Areas) with more beds per capita, a small proportion of nonwhites, and warmer winters. Since the admission rate and the bed rate are constant, the race and climate variables influence the occupancy rate through their effect on length of patient stay.

The analysis indicates that SMSA's in which hospitals are more crowded ration admissions more strictly and consequently have a lower admission rate. With occupancy rates constant, a higher bed rate implies a greater number of vacant beds per capita and therefore less possibility that an admission will delay the admission of a more serious case. Insofar as the hypothesized positive partial effect of the bed rate on admissions is concerned, in one formulation of the model a 1 per cent increase in the bed rate results in a ½ per cent increase in the admission rate. Admission rates are higher the greater the per capita insurance coverage, the greater the number of surgeons per capita, the colder the winter climate, the larger the proportion of the nonwhite population, and the lower the median family income.

The analysis of differences in bed rates among cities indicates that admission rates, emergencies, and the proportion of the city's beds in federal hospitals all are positively and highly significantly related to the bed rate. The significance of the federal bed variable indicates less than perfect substitution of federal hospital beds for other beds, possibly because nonveterans cannot use federal hospital beds. The bed rate is not correlated with the rate of population growth, which suggests that hospital bed construction "keeps up" with population growth.

These findings indicate that the three dependent variables—the occupancy rate, the admission rate, and the bed rate for short-term general hospitals—are responsive to SMSA differences in economic and demographic variables. The hypotheses developed in the theoretical analysis are, in general, confirmed.

More recently, I have begun work on analyzing SMSA differences in the use of nursing homes by the aged. The preliminary findings are consistent with the hypothesis that nursing homes are imperfect substitutes for out-of-nursing-home care for the aged. I plan further research on this important topic.

Barry R. Chiswick

The Demand for Abortion—
An Economic Analysis of Pregnancy
Outcomes in New York City

The purpose of this study is to analyze the nature of the demand for legal abortion, one of the newer and more controversial fertility control methods. Because of the high degree of

substitution that is possible between abortion and pre-conception fertility control methods on the one hand, and between abortion and births on the other, abortions are considered within the context of a lifetime model of pregnancy outcomes.

I have now completed work on the theoretical aspects of the model. Data pertaining to New York City residents from the 1970 Census and from vital statistics records presently are being prepared in a form suitable for the empirical stage of the analysis. Both sets of data are being grouped by race and by "health area," a statistical unit created by the New York City Department of Health, with boundaries corresponding to census tracts. The approximately 300 health areas present all the diversity of well-defined neighborhoods, yet still are sufficiently populous (averaging 25,000 persons) to generate a representative body of vital statistics in the course of 1 year. This analysis focuses on the periods immediately preceding and immediately following the legalization of abortion in New York (July 1970).

The study has three objectives. First, I seek to identify what factors determine the demand for legal abortion. I will approach this question directly, in the abortion demand equation, and indirectly, by analyzing the demand for conceptions and the demand for births during the period when abortion was legal. Second, I will attempt to gauge the impact of legalization on births, on conceptions, and on illegal abortions. Finally, I will assess the efficiency of abortion as reflected by the average number of births averted per abortion in relation to alternate fertility control methods. From this assessment I can determine the cost-effectiveness of abortion and thereby gain some understanding of the economic rationale underlying the substantial demand that New Yorkers have demonstrated for this service.

Marcia J. Kramer

Determinants of Infant Health

Critics of the U.S. health delivery system frequently cite the relatively high infant mortality rate in this country as one sign of the system's malfunctioning. The rate of decline in infant mortality in the U.S. has lagged so far behind the rates of other economically advanced countries since World War II that today, among these countries, the U.S. infant mortality rate is one of the highest. In addition to the obvious substantial losses entailed in a high infant mortality rate, there has accumulated in recent years increasing evidence that an unfavorable prenatal environment can retard mental and physical development even among children of school age and older. Although many studies of infant mortality have been undertaken, few have been able to isolate the independent effects of specific variables or deal with the phenomena within a general theoretical framework.

In the present study I attempt to deal with the pregnancy period and the subsequent health of the infant within the context of the household production model of consumer behavior. Within this framework, mothers produce a healthy child with inputs of market goods (specifically prenatal care) and their own time. In addition, since the mother's body functions as the mechanism of production during the prenatal period, I will take into consideration variations in her health. I regard the entire pregnancy period as a production process involving a temporal sequence of events wherein behavioral decisions and medical incidents interact to produce a given outcome.

I will use computer tapes of New York City birth, infant death, and fetal death certificates for 1970 to estimate the model. New York City routinely collects information on parental and infant health, medical care, and socioeconomic characteristics for individual pregnancies. I will supplement the socioeconomic variables on the vital statistics tapes with information from fourth-count summary tapes from the 1970 Census. In addition, I am collecting data on the location and availability of obstetricians, prenatal care clinics, and special infant care facilities in the City in order to estimate their importance in determining behavior and outcomes.

Eugene Lewit

Medical Malpractice

I have continued my analysis of medical malpractice during the past year, but on a reduced

scale while awaiting the hearings and technical reports of the President's Commission on Medical Malpractice. The reports recently became available in 1973 and a first draft of my work should be completed in the fall. These documents, especially the technical reports, should greatly expand our substantive information on the issue.

<div align="right">Melvin Reder</div>

Population and Family Economics

Introduction

A number of significant developments occurred in this area during the past year. In June 1972 several members of the population project and other NBER staff members participated in the first of two conferences on the economics of population, New Economic Approaches to Fertility, chaired by T. W. Schultz of the University of Chicago and sponsored jointly by the National Bureau of Economic Research and the Population Council. Papers presented by National Bureau staff members included Gary Becker (with H. Gregg Lewis), "On the Interaction Between the Quantity and Quality of Children"; Reuben Gronau, "The Effect of Children on the Housewife's Value of Time"; Robert Michael, "Education and the Derived Demand for Children"; and Robert Willis, "A New Approach to the Economic Theory of Fertility Behavior." The conference papers have been published as a supplement to the *Journal of Political Economy,* March–April 1973. The second conference, Marriage, Family Human Capital and Fertility, held in June 1973, featured additional papers by NBER staff members, including Gary Becker, "A Theory of Marriage—Extensions and Applications"; Jacob Mincer (with S. Polachek), "Family Investment in Human Capital"; Arleen Leibowitz, "Home Investments in Children"; James Heckman, "Child Care Programs, Women's Work Effects and Fertility"; and Warren Sanderson, "Birth Probability Approach to the Economics of Fertility." The papers from this conference are also scheduled to be published as a supplement to the *Journal of Political Economy.*

The addition of the term "family economics" to the title of the population project signals a significant expansion in the size of the staff and the scope of research on the economics of population during the past year. More fundamentally, it points to explicit recognition that the economic determinants of demographic variables at the microeconomic level are closely connected, theoretically and empirically, with the determinants of many other forms of behavior of individual family members and of the family unit as a whole. The informal connection between NBER research on the economics of population and work on human capital, labor force behavior, and income distribution that has existed in the past has become more formal this year with the addition of projects by Elizabeth Landes on the effects of specific investment in human capital on women's wage rates and labor force behavior; by Arleen Leibowitz on the effects of parental "investments" of time and money on their children's subsequent educational attainment and income; and by James Smith, who is investigating the life-cycle distribution of family income. These studies are described below (for Leibowitz' report, see the income distribution section). Each bears on issues that are of crucial importance in the research on demographic behavior, which remains the primary focus of this project.

The scope of demographic research, which in past years has focused almost exclusively on fertility behavior, has been broadened by the work on the theory of marriage by Gary Becker. Since one of the major factors affecting the desire to marry and the selection of a mate is the demand for children, Becker's theory provides important insights for the continued investigation of various aspects of fertility behavior by Robert Michael, Sue Ross, Warren Sanderson, and Robert Willis. The projects on marriage and fertility are also described in more detail in the individual reports that follow.

The increased level of research on the economics of population at the National Bureau has been made possible by the continued support provided by a grant from the Ford Foundation and by a grant received this year from the Center for Population Research, National Institute of Child Health and Human Development, U.S. Department of Health, Education and Welfare.

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

Male-Female Wage and Employment Differentials

As a pre-doctoral fellow at the National Bureau during the past year, I have written a preliminary paper entitled "Male-Female Differentials in Wages and Employment: A Specific Human Capital Model." This paper describes a model of firm-financed human capital investment in workers, providing insights into the different incentives for firms to invest in the training of female and male workers, given sex differences in labor force attachment. The model therefore provides a way of analyzing differences between males and females in wages, occupational distribution, and in amounts of on-the-job training. Implications of the model for wages, employment, and training are that:

1. The relative number and quantity of training of women will vary inversely with the volume of specific human capital investment across occupations, holding constant labor force turnover rates.

2. The relative wage of women will also vary inversely with the volume of specific human capital investment across occupations, holding constant different turnover rates between men and women.

3. As the volume of investment in specific human capital in the labor market increases over time, the relative quantity of training of women will fall and their relative wage decrease.

4. As the labor force characteristics of women approach those of men across occupations and over time, their relative wage and relative quantity of training will improve.

Despite sparse data on such variables as true labor force experience of women and labor turnover rates for both males and females, I have performed some preliminary empirical tests of the model using data on whites from the 1967 Survey of Economic Opportunity, aggregated by occupation. I used proxy variables for turnover and experience, such as average hours worked, percentage of full-time employment, and average number of children per woman in an occupation. In addition, I constructed a variable measuring volume of investment from the experience earnings profile of white males within each occupation. The results of these tests confirm the predictions of the model. I intend to do further empirical work using the Survey of Economic Opportunity data, as well as aggregate occupational data from the U.S. Census of Population for 1940, 1950, 1960, and 1970.

Elizabeth M. Landes

The Life-Cycle Distribution of Family Earnings

Since publication of the last *Annual Report,* I have begun a study of the distribution of family earnings. In previous studies of income distribution, economists have concentrated exclusively on the distribution of personal incomes and, in particular, on the income distributions of males. Insofar as this work is concerned, perhaps their most important theoretical contribution is that individual earnings exhibit considerable life-cycle variation. The argument stipulates that earnings are low early in a person's career when he is self-financing his schooling and job training. In turn, earnings later on in life increase as the returns come in from earlier investments. Employing this human capital framework, Jacob Mincer studied the distribution of white male earnings and found that the human capital model "explained" over 60 per cent of the variance in male earnings.

In view of the success of Mincer's work, I plan to study the life-cycle distribution of family earnings. Before one can understand this variance in family earnings, earnings must be separated into its wage-rate and hours-worked components. Age-related changes in family earnings reflect age variations in both hourly wage rates and yearly working time of each family member and the covariation among spouses in the wage and hours profiles. I will develop three essential aspects of the theoretical model. The human capital investment model should explain the age-wage pattern for the husband and wife simultaneously. I will develop the underlying theory for the optimal life-cycle human capital investment path for married men and women. The second aspect of the theoretical model involves explaining the patterns of life-cycle time allocation of married men and women. In my Ph.D. thesis, I developed a model that showed that these patterns could be caused by varia-

tions in age-specific wages of spouses, interest rates and rate of time preference, and variations in the nonmarket productivity of time as proxied by family size. The empirical work in my thesis also demonstrated that the extent of this movement in the relative amount of male to female market time was significant. Thus, this labor supply side could clarify considerably this pattern of family earnings. The third aspect of the model is the implied relation in personal characteristics between husbands and wives that one would predict in a theory of marriage. For this work I plan to make use of recent contributions of Gary Becker on the theory of marriage.

I am using two data sources for the empirical work, of which a sizable amount already has been completed. The first is a family tape based on the 1967 SEO sample and the other a similar family tape using the 1960 U.S. Census. Both of these tapes record the personal and labor force characteristics of both the husband and wife. For studies in a family context, this merging of records of family members represents a major advance.

James P. Smith

A Theory of Marriage

I have begun a theoretical and empirical study of marriage. The theory relies on the new approach to household behavior that figures so prominently in many studies at the Center. One basic assumption of my approach is that persons marrying expect to raise their utility above the level it would reach were they to remain single. A second is that since many men and women compete as they seek mates, a "market" in marriages can be presumed to exist. Each person tries to find the best mate, subject to the restrictions imposed by the market.

In "A Theory of Marriage: Part I" (*Journal of Political Economy,* July–August 1973) I have developed the essentials of the theory and applied them to several problems. I have given primary attention to explaining the sorting of married persons by ability, education, beauty, religion, income, race, height, and other traits. Why do persons with these similar traits—"likes"—tend to marry one another? The theory provides an answer in terms of the effects on utility—mar-

riage of likes tends to make persons better off than other sortings would.

In "A Theory of Marriage: Part II," presented at the NBER–Population Council's population conference in June 1973 and forthcoming in the *Journal of Political Economy* (April–May 1974), I extended the analysis to include caring and love between mates; the implications of assortive mating for inequality in family incomes and genetic selection over time; and life-cycle patterns in marriage, separation, divorce, remarriage, and so forth.

Currently, I am beginning to test this approach with quantitative information. I am trying to determine whether the theory can predict which marriages are most likely to end in separation or divorce. (It is known, for example, that persons marrying at younger ages are much more likely to separate than others.) I am also planning to test the implications of the theory about sorting by different traits in remarriages compared to the sorting in first marriages.

I hope eventually to incorporate these studies, as well as the results from several Ph.D. dissertations at the University of Chicago, into a single volume.

Gary S. Becker

The Economics of Fertility Control

We have recently begun a joint study of how the costs of fertility control affect fertility behavior. Economic models of the demand for children typically assume zero cost of fertility control and seek to explain differences in the number of children among households as a response to differences in the households' income, price of time, price of child substitutes, child complements, and so forth. We hope to integrate into this model some of the insights obtainable from demographic models of fertility control. This project is an extension of our separate studies of fertility behavior that appeared recently in the fertility conference supplement to the *Journal of Political Economy* (March–April 1973, Part II).

Within the context of a static theory of lifetime fertility, we hope to determine both analytically and empirically the impact of costly fertility control on the number and the quality of children.

We also hope to determine the effects of differences in the desired number of children on the contraceptive behavior of households. Finally, for homogeneous groups of households, we intend to explore the influence of alternative fertility control strategies on the distribution of the number of children within each group of households—different contraceptive practices affect not only the expected (average) number of children but also the variance and the skewness in the distribution of fertility outcomes.

Although we have as yet no adequate theory of the life-cycle aspect of fertility decision-making—the determinants of the timing and spacing of children—we hope to indicate, at least descriptively, the effects of alternative contraceptive practices on the spacing and timing of children within the household. The empirical analysis is also expected to indicate the extent to which pregnancy-interval contraceptive choices predict the mean and variance of the fertility outcome across groups of households.

The principal data to be used in this study is the 1965 National Fertility Study conducted by the Office of Population Research at Princeton University. It is still too early to say when the study will be completed, although a preliminary draft of a paper, "The 'Imperfect Contraceptive' Population: An Economic Approach," was presented at the annual meetings of the Population Association of America in New Orleans in April 1973.

Robert T. Michael
Robert J. Willis

The Influence of Schooling on Fertility Behavior

Since last year's Annual Report, I presented a conference paper that discussed the mechanisms through which the husband and wife's level of schooling might affect their fertility behavior. The empirical work dealt with the relationship between schooling level and the choice of contraceptive techniques in the context of a simple stock-adjustment model of the demand for children. The data set used was the 1965 National Fertility Study. That paper appeared in a conference volume, "New Economic Approaches to Fertility" (Journal of Political Econ-

omy, March–April 1973, Part II).

I am continuing to study contraceptive behavior. In addition to my collaboration with Robert Willis, described in the preceding report, I have recently begun to study the joint influence of schooling and I.Q. on fertility behavior. Both ability and schooling affect the opportunity cost of an individual's time, which, according to many studies, affects fertility. In addition to affecting time value and wealth, ability and schooling may alter the relative cost of achieving a given level of human capital in children (through genetic or behavioral considerations). The empirical question is, What are the separate and joint effects of schooling and ability on the couple's childbearing and childrearing practices?

I have begun to study this topic with data from the Terman sample of the gifted (children with measured I.Q. in excess of 135). This longitudinal data file has followed about 800 males and 600 females from childhood through middle age. It includes considerable information about the subject's marital and fertility behavior and contains some data on the subject's spouse. Partitioning the data set into two samples of gifted men and gifted women should provide some useful statistical control for distinguishing the influences of ability and schooling within the Terman sample. Comparisons of behavior between Terman subjects and comparably schooled couples from the general U.S. population will help identify the influence of high ability on fertility patterns.

In my recent empirical research I have been assisted by two very able and careful assistants, David Lindauer and Kathleen McNally.

Robert T. Michael

Household Production and the Demand for Children

In previous papers, I have reported results of regressions in which the number of children ever born to women who have essentially passed beyond the childbearing stage are regressed on proxies for husband's lifetime income, wife's potential lifetime market wage, and an interaction term between these two varia-

bles.[1] The results of these regressions were encouraging in the sense that the sign of the regression coefficient on the interaction term was positive, as predicted by the theory, and the regression coefficients seemed to be quite stable across several cross-sectional groups of American women (see Sanderson and Willis, 1971). The stability of these coefficients and the form of the regression suggested that secular growth in income and female wage rates might account for the decline in fertility before World War II and the subsequent upswing associated with the postwar baby boom. To test this hypothesis, I first estimated a trend equation for fertility from the 1960 Census 1/1000 sample and then added the economic variables from the interaction model to see if the trend terms could be reduced to insignificance (Willis, 1973). As it turned out, the addition of the economic variables had virtually no effect on the trend terms and the hypothesis had to be rejected.

In a paper I am scheduled to present in November 1973 to the NBER Conference on Income and Wealth, I plan to reexamine the issue of whether the household production theory of fertility behavior can account for changes in cohort fertility and to examine, as well, certain additional or alternative hypotheses such as Richard Easterlin's intergenerational relative income hypothesis. I plan to pool several cross-sectional surveys taken at different points in time, such as the 1960 and 1970 Census Public Use Samples, in order to estimate earnings functions for males and wage functions for females that may better accord with the ex ante expectations of couples during their childbearing period than did the essentially ex post measures used in previous papers. I also have data on the reproductive histories of a number of groups of women from the 1965 National Fertility Survey. I hope to be able to determine the effect of variations of temporal macroeconomic conditions (e.g., unemployment rates) on age-fer-

[1] Warren Sanderson and Robert Willis, "Economic Models of Fertility: Some Examples and Implications," *NBER 51st Annual Report* (September 1971), pp. 32-42. Robert J. Willis, "A New Approach to the Economic Theory of Fertility Behavior," *Journal of Political Economy*, Supplement (March–April 1973), pp. 32-42.

tility schedules of individual women in the survey.

Robert J. Willis

The Effect of Economic Variables on the Timing and Spacing of Births

I am attempting to determine how economic factors modify couples' decisions about the optimal timing and spacing of births. The phenomena I am investigating include the age of husbands and wives at the births of their first and last children and the length of the intervals from marriage to first birth and from first to last birth. Still to be studied are the intervals between successive births and the age of each parent at intermediate births.

Using the data from the 1965 National Fertility Study, conducted by Princeton University's Office of Population Research, I am analyzing primarily through regression analysis the effects of education, income, family size, and other variables on the timing and spacing of births by white, nonfarm American women. I study Roman Catholics and non-Catholics separately. My preliminary findings for non-Catholics reveal that an additional year of schooling for the wife increases the age at first birth for both the husband and the wife by about 5 months; but an additional year of schooling for the husband has a statistically insignificant effect on the husband's age at first birth, although it raises the wife's age by 3 months. There are significantly shorter intervals between first and last births of women with more education, whether or not the number of births is held constant; thus, the effect of an additional year of schooling for the wife on her and her husband's ages at last birth is to increase each, but only by 2.6 or 2.7 months. The more education the husband has, the longer is the interval from first to last birth; however, the positive coefficient on husband's education is not significantly different from zero.

The husband's income in 1965 does not appear to affect timing and spacing decisions significantly. Since couples cannot reliably predict their future incomes, their incomes in 1965 may be less relevant to timing and spacing decisions than the average future incomes they might have

expected based on the husband's education, occupation, place of residence, and so on. I have just begun introducing this "predicted income" variable into regressions; it appears to be more relevant to early timing decisions—e.g., wife's age at first birth—than 1965 income but less relevant in later decisions such as the interval from first to last birth.

The education and income variables are insignificant in determining how long after marriage a couple starts to have children; only the number of children is significant.

The data suggest that if a woman postpones her first birth by 1 year, she is less than 1 year older when she stops having children, partly because she may have fewer children or may have more children within a shorter time span. In the case of husbands, however, those waiting a year to have the first child are 1 year older at the last birth, whether or not the total number of births is held constant.

Roman Catholic couples are affected quite differently by some of these variables. For example, for them the education of the wife and of the husband is less significant in regressions on the wife's or husband's age at first or last birth. The signs of the coefficients actually reverse when the regression is run on the total birth interval: The wife's education has a positive effect whereas additional education for the husband shortens the interval from first to last birth.

As for non-Catholics, if a Catholic woman postpones her first birth by 1 year, she is less than 1 year older at her last birth; the compressions of intervals for a given family is about the same as for non-Catholics, but there is less reduction as a result of having had fewer children. If a Catholic husband is 1 year older at the first birth, he will be nearly 1 year older at the last birth if family size is held constant. Unlike non-Catholics, his older age at first birth will shorten the total interval from first to last birth by reducing the number of children the couple has.

Sue Goetz Ross

Toward Broadening Economic Models of Fertility

One of the most important aspects of the ap-

proach to the study of fertility adopted by the National Bureau is its emphasis on the inter-relationship between the theoretical and the empirical facets of the study. This emphasis is important because it unifies the efforts of those working on fertility and helps to ensure that their studies build on one another. It is, therefore, important that the underlying theoretical structure have implications that match empirical phenomena as closely as possible.

The theoretical structure underlying the National Bureau approach to fertility analysis is derived from the work of Becker (see G. S. Becker, "The Theory of the Allocation of Time," *Economic Journal,* September 1965) and Willis (see R. Willis, "A New Approach to the Economic Theory of Fertility Behavior," *Journal of Political Economy,* Supplement, March–April 1973). The household is regarded essentially as an entity that uses the time of household members and purchased goods and services to produce the final household commodities desired by the household. It also assumes a single "representative" utility maximizing household. In addition to providing a framework for research, this approach also raises some questions. (1) Are the implications of this model applicable to aggregates as well as to single households? (2) Is it necessary to assume the "rationality" of the "representative" household or can similar implications be derived without this assumption? (3) Can implications be derived for discrete as well as infinitesimal changes in exogenous variables?

In the past year, I have shown that it is possible to place the household production portion of the model into an aggregate context in which postulates on group behavior replace assumptions concerning individual utility functions or preference orderings. In this context, it is possible to derive aggregate implications, without assuming "rationality," which are almost identical to those derived by Willis. Thus I have shown that the theoretical structure underlying the National Bureau approach to fertility analysis is broad enough to encompass varieties of "non-rational" behavior in the aggregate. For the basic framework in which this aggregate analysis has been carried out, see Warren C.

Sanderson, "Does the Theory of Demand Need the Maximum Principle?" in P. David and M. Reder, eds., *Nations and Households in Economic Growth: Essays in Honor of Moses Abramovitz,* New York, Academic Press, forthcoming, 1974.

In addition to my theoretical work, I am making progress on an analysis of monthly birth probabilities for native white women that are specific for single year of age of mother, order of birth, and current year from 1920 through 1966, and presented a paper on this subject at the June 1973 population conference sponsored by the NBER and the Population Council.

Warren C. Sanderson

4. FINANCIAL AND INDUSTRIAL INSTITUTIONS AND PROCESSES

Financial Institutions and Processes

Introduction

The study of the effects of inflation on financial markets, discussed in detail in reports that follow, is again the major element in the Bureau's financial research program. Aside from this investigation, three other studies are reported on individually: Wilbur Lewellen's examination of the portfolio performance of individual investors; a new study by Donald Farrar on multi-index generalizations of the capital asset pricing model; and a new study by Henry C. Wallich on the factors affecting differences among countries in their monetary behavior. Two reports discussed in previous years are close to the manuscript stage. One is David Kresge's microeconomic study of the behavior of the commercial banking industry during the period 1965–67, and the other is Leo Troy's study of the financial resources of the American labor movement.

A paper by Anthony J. Curley and Jack Guttentag, the last from the Study of Interest Rates, financed by the Life Insurance Association of America, has been revised by the authors and has passed Board review. Raymond Goldsmith's monograph on *Institutional Investors and Corporate Stock,* a revision of the earlier report to the Securities and Exchange Commission, was published in July.

Robert E. Lipsey

The Effects of Inflation on Financial Markets

A study of the effects of inflation on financial markets was undertaken in 1971 with the support of the Life Insurance Association of America. The study is nearing completion and comprises the five parts reported on below—financial institutions, interest rates, household saving, convertible bonds, and common stocks. These are the areas in which it was thought that important inflationary effects occur and in which recent professional research had suggested additional work would be fruitful. It has been widely believed that one effect of inflation is a shift from fixed dollar securities to other assets that are to some degree protected against loss of purchasing power due to inflation, and that financial instruments such as convertible bonds and common stocks were purchased as hedges against inflation. Prices and rates of return on different securities adjust to changes in inflationary expectations. Lenders and borrowers then respond to the interest rate and price changes and to the degree of uncertainty about future changes. The present study is an empirical and theoretical analysis of such effects.

Phillip Cagan

Investment Policies of Major Financial Institutions under Inflationary Conditions

The strong inflationary surge in the United States beginning in 1965 had major effects on the new investments being made by our major financial institutions via the impacts on the flow of new funds available for investment in most of these institutions, and on the demand for funds from different groups and types of borrowers. These shifts in supply and demand, together with growing expectations of further inflation, significantly changed the general level of yields available on new investments, and equally, if not

more important, altered the structure of relative yields available on different types of new investments. In addition, this inflationary period involved a major increase in the use of various income participation features in mortgage loans and "equity kickers" (such as warrants and conversion privileges) in other debt contracts.

Our study of the impact of inflation on the investment position and policies of major institutional investors must consequently identify the effect of inflation on the amount of funds available for investment and then analyze the reasons for the shifts that are detected in the proportions of different types of new investments. Changes in the patterns of new investments that represent changes in investment *policies* must be carefully distinguished from shifts in the allocation of new investment funds that merely reflect the response of each institution to the changing relative rates of return. Moreover, where there is evidence of changes in investment policies, it is necessary to determine whether (and to what extent) these policy changes can properly be attributed to inflation and the expectations of more inflation as distinct from other considerations.

In our report last year we supplied a general description of the set of interrelated studies of these issues we have underway. In particular, that report outlined our basic research methodology, which involves statistical analysis of data drawn from individual institutions and companies as well as the analysis of aggregate data for different types of institutions. We also emphasized the important complementary and interacting role of confidential interviews with several of the senior investment officers in a selected sample of companies and institutions.

The value of this multiple approach in our research has been clearly shown in our investigation of the investment commitment policies of life insurance companies and of other major institutions with fixed dollar liabilities. Jones' well-known study of life insurance company investment policies through the early 1960s[1] had found that, in contrast to earlier years, in-

surance companies were placing increasing importance on maximizing the average overall rate of return on their investments. But most of the investments of these companies involve advance commitments of funds at currently determined rates that may be drawn down by the borrowers over various future periods,[2] and Jones found that the volume of new commitments was primarily determined by the gap between anticipated flows of investible funds in future periods and the volume of existing commitments that would be drawn down from these prospectively available funds. Within the context of this policy of being fully "loaned-up," there was evidence that the new commitments made *in each period* would be shifted toward investments offering higher returns; but this dominant "loaned-up" objective precluded shifts *between periods* in timing new investment commitments, such as would be required by the alternative objective of maximizing their rates of return over time. In particular, Jones discovered no evidence that the companies tried ". . . to make commitment decisions so as to increase their investment returns over time [by] concentrating new commitments in periods of high interest rates . . ." (p. 332), and his final conclusion was that "In sum, although the results leave much to be desired, they do lend credence to the loaned-up thesis . . . [but] the rate-of-return [over time] hypothesis was quite firmly rejected by the analysis."[3] Since inflation and the expectation of further inflation change yields and the returns prospectively available in the future, these earlier conclusions posed serious issues for our own research, especially in view of the predominant role of forward commitments in the investment posture of these important institutions.

On the basis of intensive interviews with senior investment officers of several companies

[1] Lawrence D. Jones, *Investment Policies of Life Insurance Companies,* Division of Research, Graduate School of Business Administration, Harvard University, Boston, 1968, pp. 16-20.

[2] In the case of loans to industrial concerns and finance companies in the so-called "private placement" market, the funds are typically drawn with a delay of several months, and for mortgage commitments, the interval is more typically several calendar quarters and varies by type of property mortgaged.

[3] Jones, *op. cit.,* p. 370. Jones also found no confirmation of the hypothesis that the level of liquid assets influenced the level of new commitments made, and our research confirms this conclusion.

and detailed analysis of the confidential internal data of these and a cross-section of other companies, it is clear that the pronounced swings in expected interest rates that accompanied the surge of inflation after 1965 did encourage a number of life insurance companies to alter the timing of their forward commitments according to their interest rate expectations. Indeed, four of the five companies interviewed in most depth clearly adjusted their forward commitment positions significantly during at least some portion of the period 1965–71 in response to interest rate expectations. In every company, however, the extent of these intertemporal reallocations of commitments was limited by strong dislike of both borrowing and the accumulation of liquid assets as a means of capitalizing on interest rate expectations, by a host of organizational problems and concerns over long-term borrower-lender-agent relationships, and by the competitive risks involved in deviating substantially from general industry practices.

Although our work substantiates the dominant influence on new commitments of expected free investible funds, the relationship is not a simple one between aggregate dollars of new commitments of all types and dollars of free expected funds (as Jones had used in his statistical analyses). Rather, our work shows that (1) particularly because of differences in the mean time pattern of takedowns, different (although interrelated) policies apply to commitments involving industrial loans, and to one-to-four family, multi-family, and non-residential mortgages; (2) for each type of asset, the active decision and control variables are the *ratios* of new commitments of each type to (total) expected available funds in relation to the corresponding ratio of the stock of currently outstanding funds; (3) there is a "desired" or "target" ratio for each type of asset that, among other things, reflects relative available returns and is also a function of interest rate expectations; (4) there are policies of progressive adaptation and successive more-or-less gradual adjustments of the actual ratios to the desired target levels for each type of asset, but the actual pace of the adjustment to desired levels also reflects changes in available supplies of loans (i.e., borrowers' demands for each type of

credit) and a "ratchet-effect" by which the pace of any decline in a commitment-stock-ratio is reduced as it falls relative to its historical norms.

Not only is this model of the determinants of investments through forward commitments based on and consistent with our field evidence, but we have also shown that it is theoretically implied by an assumption that insurance companies are in fact dominantly motivated by the goal of maximizing their rates of return over time in a market context characterized by both change and uncertainty.

Our econometric analyses incorporating this richer policy structure have yielded very satisfactory results with statistically significant coefficients on virtually all elements in the equations for each type of asset in the insurance company data.[4] In particular, our statistical work confirms that the volume of commitments of each type must be explained by adjustments in the respective *ratios* of commitments to expected fund flows in a process of progressive movements *toward* an equilibrium portfolio balance rather than by the simpler structures fitted in previous studies. More generally important, our econometric analysis reveals the strong and statistically significant influences of both *relative* yields on different types of assets *and* expectations of future interest rates, which are implied by the dominant objective of maximizing the rate-of-return-over-time.

In addition to these studies, we have underway similar studies of the commitment process and determinants of shifts in the ratios of mortgage to bond holdings of larger mutual savings banks and other institutions with substantial portfolios of these assets, again using depth interviews with responsible officers and individual company as well as industry data. Although less far along, the results of these additional studies indicate that the policies of these other

_____

[4] The effect of changes in available supplies of loans of each type was strongly indicated in our field interviews, but careful measurement of the net effect of this factor in an econometric setting requires development of a full set of supply *and* demand equations for simultaneous solution over each of the submarkets. Our work on this fuller structure is still in process, but the results in our single equation fittings reported in the text are clear on all the other elements, and our work to date indicates this further factor will also be confirmed in the broader set of equations.

institutions are likewise directed toward seeking a portfolio balance to maximize rates of return over time with due allowance for risk. However, in their different institutional settings, they do so by adjusting more quickly than life insurance companies. The reasons for these differing degrees of flexibility are being explored, along with their effect on realized rates of return.

These results of our studies of the commitment policies and the determinants of the bond-mortgage ratios in all of these institutions lead to several conclusions with respect to the effects of inflation on the investment decisions of these important institutions.

1. Both the amount of inflation to date and the expectations of further inflation significantly shift the general level and the structure of relative yields available on new investments at any given time. These changes in yields change the proportionate allocation of new investments in all of these institutions. This response is an adaptation to the new set of conditions at least partially determined by the inflation *within* the context of an unchanged set of investment policy objectives and patterns of reaction to the relative returns available on different investments. In this respect, inflation changes portfolio allocations by changing the conditions to which these institutional investors react rather than by changing their investment policies as such.

2. Expectations of further inflation clearly condition expectations of future interest rates, which in turn further change the current cross-sectional allocation of investment funds and also modify the inter-temporal pattern of investment commitments. Once again, these influences are adaptations to changing conditions within the context of a continuing policy geared to maximizing (nominal) rates of return. After allowing for the impact of inflationary expectations on the expectations of future yields (including the effect on future yields of the prospective changes in monetary policy that the prospective rate of inflation is expected to induce), we find no independent effect of inflationary *expectations* on the policies followed by life insurance companies or by other institutions in allocating funds between bonds and mortgages in their investment portfolios.

3. Inflation also affects investment allocations by changing borrowers' demands for funds through private placements, bond issues, and different types of mortgage loans; by affecting the supplies of funds available to all of these institutions for new investment; by increasing expenses; by generally adding to uncertainties regarding the outcomes associated with investment decisions; by increasing risks of "disintermediation"; and by increasing needs for liquidity.

4. In addition to these conclusions regarding the impact of inflation, our work on all these different types of institutions with fixed dollar liabilities indicates that fundamental modifications are required in the prevalent views, dating from the interpretations of Irving Fisher at the turn of the century, regarding the *mechanism* by which expectations of inflation affect nominal interest rates. Both Fisher and many contemporary economists hypothesize that market interest rates will rise in the face of expected inflation because of the increased demands of borrowers who can repay in funds of reduced purchasing power, *and* because lenders are expected to require higher nominal rates in order to protect the real returns on their investments, and thereby the purchasing power of their capital. All of our field work, however, finds that in making decisions to acquire assets to be held against liabilities denominated in nominal dollars, institutions seek to maximize the rate of return over time in nominal dollars, and they do not withhold funds until returns have risen enough to preserve purchasing power *per se.* Nominal interest rates on mortgages and bonds move up with inflation because of increased borrower demands, perhaps because of the purchasing power allocation decisions of *other* investors (particularly individuals), and because of the effect of inflation in reducing the investible cash flow of funds *available* for investment by institutions with fixed dollar liabilities, but *not* because of purchasing power considerations in the investment decisions of institutional investors (a very large group).

Other parts of our work in process can be summarized more briefly. One of the important developments in the investment activities of major institutional investors during the inflation-

ary build-up from 1965 to 1970 was the increasingly prevalent use of income participation features in mortgage loans and "equity kickers" in other debt contracts. With respect to income participations, in addition to analyzing various available tabulations of industry-wide data, we are interviewing lending officers in different companies in each of the major types of financial institutions that are important in the multi-family and nonresidential mortgage markets and are examining a good cross-sectional sample of individual mortgages made in these years. Among other things, we are concerned with the trade-offs between regular coupon and participation features, the way the participation features were tailored, and the extent to which prospective inflation entered into the assessments made at the time of the loan of the expected incremental values of the participations built into the loans.

Similarly, our study of equity kickers cut across different types of institutions important in the private placement market. This research involves in-depth interviews (also partially completed) with lenders, borrowers, and agents, and a large sample of data from public sources and mail questionnaires. In order to deepen our understanding of the policies involved, we are investigating the factors on both the lenders' and borrowers' side that contributed to the use of a kicker in specific deals. We have found that the equity kickers must be segmented in three dimensions according to credit rating, type of kicker used, and the assessments made of the prospects of the underlying stock at the time of the deal. Interestingly enough, our work to date indicates that kickers were primarily an "add on" in tight credit markets and that *within this context,* assessments of prospective inflation generally did not enter significantly into the decision to use a kicker, or in the assessment of its prospective value, nor the choice of type of kicker. Insofar as past and prospective inflation were responsible for the tightness of credit market conditions, the use of kickers may, of course, be *indirectly* attributed to the inflation itself. However, it is significant in this regard that the use of kickers virtually ceased in late 1970 and 1971 with the onset of recession and distinctly easier credit market conditions, even though the rate of inflation was still quite high.

Other studies underway have to do with institutional investments in common stocks [5] and with the effects of inflation on the volume of funds available for investment. One of the principal sources of funds for investment in the general accounts of life insurance companies, for instance, is the net investment income on existing assets that largely represent the reserves on outstanding policies. This net investment income thus depends on interest rates and a cumulative distributed lag on the amounts and mix of new insurance sold. Our analysis of the demand for new insurance has found that changes in real insurance protection per capita are negatively related to changes in real per capita wealth but very strongly and positively related to changes in real per capita wages and salary incomes. In addition to the indirect effects of inflation through these other variables, we also have found a very strong negative and direct effect of the rate of inflation itself. In each case, the direction of these effects in our statistical analysis correspond to the signs indicated in our theoretical analysis of the demands for insurance.

Apart from this mixture of direct and indirect effects of inflation on the funds available for investment by way of insurance sales and earnings on policy reserves, there are additional effects on expenses, needs for liquidity, and the rate of voluntary repayment of assets held in their investment portfolios. In addition, and very important, there are further indirect effects of inflation on the funds available for discretionary investment by way of the drains for policy loans (which are passively supplied at historically determined and fixed rates, usually 5 per cent). We find the primary determinants of policy loans to be the stock of policy reserves (the size of the pool that may be drawn down) and the "opportunity cost" to the borrower of bank loans as an alternative source of funds for spending rather than investing. We did not find any stable and statistically significant response of policy loan borrowing to the excess of current bond yields over the policy loan rate, and thus found

no clear evidence of disintermediation by policy holders for investment purposes.

John Lintner
Thomas Piper
Peter Fortune

Interest Rates and Commodity Prices

I recently completed a paper, "What Do Regressions of Interest on Inflation Show?", which describes the restrictions on the structure of the economy that would have to be assumed to be operating if Irving Fisher's method of regressing nominal interest rates on current and lagged rates of inflation were to provide a reliable way of estimating the way people form expectations of inflation. The paper then describes the statistical biases that can result if those restrictions are violated. The biases can be quite severe and can give rise to long distributed lags of interest on inflation even when expectations of inflation respond to actual inflation with a short distributed lag. The possible presence of such a bias is in principle capable of explaining the "Gibson paradox"; that is, the high correlation between interest rates and price levels over time. This paper is to appear in a forthcoming issue of the *Annals of Economic and Social Measurement.*

I also have completed a paper titled "The Fundamental Determinants of the Interest Rate: A Comment," which describes a statistical identification problem that characterizes some recent attempts to implement Fisher's theory of the impact of inflation on interest rates.

Thomas Sargent

The Influence of Price Expectations on Household Saving

The purpose of this study, which is now almost complete, is to examine the influence of personally held price expectations on a household's saving and the composition of its portfolio. I have analyzed aggregate time-series data from the National Income and Flow-of-Funds accounts as well as two large sets of micro survey data. The two microdata sets are based on information provided in:

1. The Consumer Anticipations Survey con-

ducted by the Bureau of the Census in collaboration with the NBER in five 6-month waves in 1968–70.

2. The panel survey conducted by Consumers Union of its members during the late 1950s.

I have approached all three data sets within the framework of a model that relates household saving (or one of its components) to income (usually disaggregated as to source), existing stocks of real and financial assets (these, too, are usually disaggregated), demographic characteristics (age, family size, etc.), and price expectations. For the aggregate data and the CAS data set, the horizon for the price expectations is 1 year in the future, whereas for the CU sample, there are three reference periods of 5, 10, and 20 years in the future. I prepared the price expectations series for the aggregate data from surveys conducted quarterly by the Survey Research Center at the University of Michigan.

For the aggregate time-series data, I have estimated equations for several definitions of total saving and for individual components of various disaggregations of total saving. In the case of the household surveys, however, data limitations have for the most part precluded any analysis of total saving, and I have focused mainly on households' demand for financial assets.

The results seem to me to be very suggestive. The time-series results quite clearly suggest that expectations of inflation have a positive overall effect on saving, a finding that is in keeping with the view that has been advanced for a number of years by Katona and his followers. The survey results, on the other hand, can be summarized as follows:

1. The results are much sharper statistically with the CAS data set than with the CU data set. Since the horizon in the CAS sample is 12 months, but a minimum of 5 years in the CU sample, it is tempting to conclude that short-term price expectations are more significant in a household's saving and portfolio management decisions than price expectations over a long horizon.

2. Both microdata sets provide strong evidence that the relationship between saving and price expectations is not homogeneous across wealth. In particular, the evidence from both

data sets is that price expectations are important principally for households of moderate wealth, those with assets between $25,000 and $75,000.

3. The results from the CU sample exhibit moderate, yet clearly discernible, evidence that the strength of the relationship between saving and price expectations varies directly with the confidence with which the expectations are held.

4. Because the expectations involve horizons of different lengths, it is impossible to say whether the results from the two microdata sets are consistent with each other. However, for the two categories for which a direct comparison is possible, the results for a horizon of 12 months appear to be consistent between the equations from the CAS sample and those from the time-series analysis.

<div align="right">Lester D. Taylor</div>

Convertible Bonds

The central purpose of this study is to explore data on convertible bonds for information on the impact of inflation on security yields. It was clear from the outset that a model of the determinants of convertible bond values was needed. Because of the almost preponderant influence of stock and—to a lesser extent—straight bond values on the values of convertibles, the study had to develop a model that looked beyond these influences (there being no point in studying convertibles to learn about stocks and straight bonds). Apart from the stock value (i.e., what the convertible is worth if converted) and the straight bond value (what the bond is worth without a conversion feature), the key factors affecting the value of convertibles are the dispersions in the distributions of the stock and bond values. The measures of these dispersions are often regarded as indicators of the riskiness of the corresponding stocks and bonds.

The value of a convertible is higher relative to the value of the underlying securities the higher the perceived risk of these securities ("potential volatility of prices" may convey more than "risk"). This relation follows from the essential nature of convertibles. A convertible is worth at least the higher of its two component securities. To the extent that yields on debt and

equity both reflect real return on capital, they will vary together. However, expected changes in the rate of inflation tend to cause these yields to diverge as these changes are anticipated in new security prices. Uncertainty over the prospective changes in the rate of inflation would discourage definitive anticipation of such changes in fixed yields and increase the attractiveness of a flexible security that offered the better of either world. By incorporating the putative advantage of equity over debt in a period of increasing rates of inflation with the relative advantage of debt in periods of falling rates of inflation and general economic uncertainty, convertibles appeal to the demand for flexibility (or for a hedge). As a result, their prices rise. This rise, which would be evident as an increase in the value of a convertible that is *not* explained by changes in the underlying stock and bond values, would *not* reflect the *expectation* of inflation but merely the *uncertainty* over the possibility of price changes—up or down. The *expectation* of inflation would be evident, rather, as rising prices of equity relative to debt as the market sought to increase debt yields to compensate for the anticipated adverse impact of the inflation. Likewise, *anticipation* of a decline in the rate of change of prices would cause the price of debt to rise relative to that of equity, with the effect on convertibles limited to the responsiveness of convertible prices to straight debt prices. Increased *uncertainty* with respect to a decline in the rate of inflation, however, would lead to an increase in convertible prices relative to debt prices. Only if the expectation of inflation were associated with a general increase in the level of uncertainty about future security prices and rates of inflation would relative values of convertibles reflect information about the expectation of inflation.

This reasoning suggests the potential usefulness of a model that separates changes in convertible values into two parts: the impact of changes in the values of the underlying securities and the impact from changes in the perceived volatility of these securities. The study has tested such a model and used it to infer the riskiness of debt and equity over time. We expect that the study eventually will include separate series on the risk of stock, bonds, and

convertible bonds monthly and across securities.

Stanley Diller

Stock Values and Inflation

This study has involved the compilation and comparison of available stock price indexes for ten Western countries plus Japan with corresponding commodity price indexes to provide a general indication of how stock values have kept pace with inflation. The data allow a comparison of stock values and commodity prices over time and among countries. Except for wartime and other inflationary periods, stock values have generally risen on the average faster than commodity prices. But this does not indicate how stock values are affected by inflation. In many cases stocks do not keep up with prices in the initial stages of an inflation, and often they decline in the terminal stages. The question then is, Do stocks respond to changes in the rate of inflation over the long run? A comparison of the various countries for World War II and subsequent years shows that stocks did rise more in response to greater inflation, but only after a long lag. In most countries during the 1940s both stock values and prices rose, but prices rose more than stocks. It took until the mid-1950s or later for the value of stocks to reach and pass their 1939 levels in real terms.

A short paper presenting these results and the basic indexes is being revised and extended to cover more countries.

Phillip Cagan

Individual Investor Portfolio Performance

This project is an investigation of the investment portfolio performance of a large sample of individual investors during the 1960s. A retail brokerage firm with nationwide operations has made available a record of the portfolios and trading activities of some 2,500 investors randomly selected from accounts open on December 31, 1970. It is thus possible to measure returns realized, to assess them in the context of risk positions assumed, and to compare them with standards of the concurrent performance of mutual funds, random portfolios, and market indices. Transactions costs can be identified

explicitly and hypotheses relating to the impact of portfolio size, trading frequency, and degree of diversification on performance will be tested. This data base provides the first look at *actual* individual investment activities.

The project has been rounded out with a survey addressed to the individuals in the sample, of whom some 1,000 responded. The questionnaires contain information on individual demographic characteristics, income and wealth positions, investment strategies, and investment objectives. We will thus be able to examine additional hypotheses concerning relationships between portfolio performance and age, income, wealth, family status, sources of investment advice, time spent on portfolio management, and other personal attributes.

The questionnaire data have been recorded and analyzed, return relatives on some 4,000 securities have been calculated, and the individual portfolio positions, by month, for the period 1964 through 1970 have been identified. These systems tasks have consumed all the project energies to date. Performance calculations are now in progress, and results should be available shortly.

Wilbur G. Lewellen

Empirical Tests of a Multi-Index Generalization of the Capital Asset Pricing Model

The capital asset pricing model developed by Sharpe, Lintner, and others combines to an unusual extent powerful theoretical properties in its more generalized formulations with easy applicability to a number of real-world measurement problems in a simplified, single index formulation. The most common of the model's empirical applications have been to analyses of investment returns on individual securities and to relationships between risk and returns obtained on portfolios containing such securities. As a result, the model has become something of a fad not only among academics but also on Wall Street.

Empirical applications of the model so far have relied on its single index formulation. Indeed, most practitioners may not realize that any other formulation is possible. It should be pointed out, therefore, that a single index model

is essentially equivalent to a "single factor" approximation of the full model, which could have as many dimensions as there are alternative investment opportunities. Any other factorization is, of course, possible and potentially useful in a number of empirical applications.

A number of recent studies have cast doubt on the robustness of the capital asset pricing model's single factor (or single index) formulation. They point to the existence of systematic deviations between actual and postulated risk/return relationships and the fact that such deviations tend to be quite unstable from one time period to another. Over some intervals high-risk securities and portfolios as a group tend systematically to outperform their risk or volatility adjusted expectations, whereas low-risk portfolios fall short of these levels; during other intervals, the reverse occurs.

The current project focuses on the capital asset pricing model's empirical stability in a "multi-index" formulation. Those persons who have examined the factorial complexity of securities price movements in the past (Farrar and King) have concluded that a single index factorization does not satisfactorily reproduce the variance-covariance structure of actual returns. If so, instabilities of the types detected would follow directly from this fact.

The purpose of the project is to analyze the covariance structure of security price movements, determine that structure's factorial complexity and, subsequently, identify and quantify each of the underlying factors. Once appropriate indices of security price movements in a number of identifiable subsectors of the market have been constructed, their usefulness as variables to explain (and eliminate) systematic errors in risk/return relationships of the type that persist with single index formulations of the model will be examined.

Two principal data bases have been developed for the study up to this point. The first is a PDE (price, dividends, earnings) file obtained from Investors Management Services, Inc., a subsidiary of Standard & Poors. This file contains sparce historical data on 1,800 industrial companies and a variety of financial, utility, and transportation companies from 1958 to 1962. From 1962 to the present, however, the data are relatively complete; the bulk of the study's analyses, therefore, are centered on a subset of monthly returns for 623 companies drawn from 92 separate industry groups. Comparable data for almost 1,300 firms from the same industries are available for the second half of the period (1967–72) and are employed for a number of comparative analyses. These data form the base whose factorial complexity has been analyzed and from which market sector indices are being constructed.

Monthly returns for 150 registered investment companies over the period 1960–69 and for 49 such companies through December 1971 will be utilized for the second stage of the analysis —to test the value of second, third, and subsequent "sector indices" within the context of an enriched multi-index capital asset pricing model.

As an initial step, investment returns for 623 companies over the period 1962–72 and for 1,300 companies over the last half of that period have been reduced by aggregation to data on 92 industry groups containing full information on three or more included firms throughout the period. (As will be indicated below, the loss of information resulting from this initial reduction may have been severe, leading to second thoughts about its wisdom.)

Factor analyses of returns by these industries have been conducted and evaluated. They suggest that at least *four* factors may be required to reproduce more adequately the variance-covariance structure of securities price movements. Various analytic and subjective rotations of the four principal factors obtained from these data have been performed in an effort to identify their basic character and to allocate each included industry to the sector that it most closely resembles. Results to date in this portion of the study have not been encouraging.

Although the first or "market" factor carries its accustomed heavy weight in explaining systematic variations of returns in the marketplace, the second through fourth factors relied on to reduce remaining sources of systematic covariation among actual returns prove to be elusive in both composition and interpretation. Allocations of industry indices to derived market sectors have proved to be exceptionally sensitive to one's choice of the factors among which

they are distributed. The interpretability and the distinctness of subgroups so formed also have proved to be disappointing. Although the centroids among which industries are distributed generally are orthogonal by construction, centroids derived after the fact from subgroups of industries allocated to these foci often display extremely high intercorrelations, in the vicinity of .90 to .95, and occasionally even higher. The impression one gains of such efforts is that a single, amorphous swarm of 92 industry vectors in 120 dimensional observation space are being distributed almost arbitrarily among different sets of artificial foci.

Two principal lines of analyses currently are under consideration. The first is simply to proceed as originally planned, by applying various sets of the four indices constructed to date, within the framework provided by a multi-index generalization of the capital asset pricing model, to returns on registered investment companies over the 1962–72 time period. Although the sector indices are far from orthogonal, they nevertheless do span the four-space determined by initial analyses to satisfactorily reproduce actual covariations in security price movements. Perhaps they will successfully pick up and eliminate systematic errors in risk/return relationships that remain with single factor formulations of the underlying model.

In addition, however, efforts to improve the stability and interpretability of the indices employed for this purpose may be undertaken by by-passing the study's initial step of aggregating individual companies into conventional industry classifications. Problems with such classifications are notorious and the loss of information from aggregation at this level may outweigh computational savings obtained from such a step. Reviews of the feasibility and desirability of this option will be undertaken in the near future.

Donald E. Farrar

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

Experience since World War II, if not earlier, suggests that many countries tend to exhibit characteristic differences in monetary behavior. Some of this behavior involves policy choices such as the degree of price and exchange rate stability maintained. Some, such as the demand for money, reflects institutional factors and the preferences of firms and households. To some extent, these differences seem to reflect discernible economic conditions, such as the degree of development or the degree of export orientation. To a large extent, no doubt, they reflect national peculiarities and historical experience. It seems possible to examine the influence of discernible economic conditions by means of a comparative approach employing country cross sections. This method often permits observation of relationships among variables over a much wider range than is possible using only national data. Although subject to numerous reservations concerning the applicability of regression techniques, the "cross country" approach avoids some of the pitfalls of time-series investigation for single countries. The variables were selected according to a criterion of significance for monetary behavior, although some of them pertain to the real sector. The data already have yielded some interesting conclusions—for instance, per capita income, openness, interest rates, and inflation were found to be significant determinants of the demand for money. A variety of preliminary results were obtained with regard to the influence of significant monetary variables on economic growth.

Currently, we are examining the variables with respect to their effect on the demand for monetary reserves and on inflation. We also plan a review of previous results concerning economic growth.

For a good part of the data, usually standardized by GNP, trends and measures of variation have been computed. Facts concerning the stability of variables, when seen in the context of the degree of economic development or of GNP structure, often yield interesting insights into the problems that developing countries in particular face. We intend to explore along these lines once the work currently underway has been completed. This work is being carried on jointly with William Dodson.

Henry C. Wallich

Industrial Institutions and Processes

Introduction

A considerable effort was devoted during the year to develop an agenda of promising research directions in industrial organization. Current research has focused on six subjects: (1) the development of a microdata bank; (2) studies of rates of return; (3) studies of product diversification; (4) analysis of the effects of advertising; (5) railroad productivity; and (6) the economics of the performing arts.

The development of a data bank, under my supervision, has consisted primarily of merging information, drawn from various private sources, for approximately 1,500 firms. These data have been used in one of two studies underway on rates of return. Specifically, I have been examining the role of firm versus industry or market variables in explaining profit rate differences. A second study of rates of return, conducted by Henry Grabowski and Dennis Mueller, is focusing on the return to various forms of investment outlays of firms. Specifically, Grabowski and Mueller are concentrating on the rates of return on investment in research and development as compared to other forms of investment, and to differential returns depending on the sources of capital funds used in financing capital outlays.

Two studies are underway on product diversification. One, which I am preparing in collaboration with Grabowski and Robert McGuckin, deals with the determinants and consequences of diversification as revealed primarily by microdata for firms. A manuscript now being prepared on this subject should be finished around the time this report appears and should shortly be followed by the draft of a second study in which Thomas A. Wilson examines the relations of diversification, growth, and mergers.

Grabowski is continuing his work on the impact of advertising outlays on various measures of firm performance such as market shares, sales, and profits.

The railroad productivity study by John Meyer and Alexander Morton is concerned with the effects of changes in the composition and location of industrial activity on the demand for inter-city freight transportation.

Guy Herregat's research, the last report in this section, will focus on the current financial condition of the non-profit live performing arts and their future financial needs.

Michael Gort

Diversification in American Industry

A first draft of the four key chapters for this study has been prepared. A summary section (Chapter I) is currently being developed, together with some revisions of the above-mentioned first draft. The manuscript, which should be available for staff review in the near future, will consist of the following five chapters:

I. The Decision to Diversify: Theory and Empirical Evidence

II. Concepts, Measures, and Trends

III. The Determinants of Diversification

IV. The Directions of Change in the Composition of a Firm's Output

V. Success and Failure in Diversification

Henry Grabowski and Robert McGuckin are collaborating with me in this study.

Michael Gort

Returns to Firm Investment Outlays

In beginning our investigation of the rates of return on various firm investments, we decided first to examine whether firms in general are overinvesting through excessive plowback of internal funds. The study of this issue was motivated by some paradoxical findings, including those reported in a recent paper by Baumol, Heim, Makiel, and Quandt in the *Review of Economics and Statistics* (November 1970). Using a large cross-sectional sample, they found that firms on the average earned far less on plowed-back internal funds than on new debt and equity issues. In explaining this finding, we hypothesize that it is attributable to age or investment opportunity differences among the firms in their sample. That is, firms that relied heavily on new debt and equity were probably firms with high investment opportunities relative

to their cash flows.

To test this alternative hypothesis, we divided a sample of 758 large corporations into two groups: (1) those that were either young themselves (created since World War II) or operating predominantly in technologies that have developed only since World War II, and (2) older companies. We found that age, defined in this way, was the key variable in determining firm rates of return. Old companies tended to earn roughly the same relatively low rates of return on both plowed-back internal funds and new equity issues; young companies tended to earn substantially higher returns on both plowback and new equity. As a further check on the importance of age, we examined the effects on stock prices of dividend payments versus retention of earnings for young and old firms. Previous studies had typically found that dividends were preferred to retentions by the market, indicating an overinvestment via retention of cash flow by most companies. When the age factor was included, we found that the young firms either were not overinvesting at all, or were overinvesting to a much smaller extent; the old firms, on the other hand, were overinvesting to an even greater extent than the aggregated regressions indicated. Thus, the importance of the age factor was clearly illustrated.

The above results are reported in our paper "Life Cycle Effects on Corporate Retention Policies and the Efficiency of the Capital Market." Since completing this paper, we have tested a number of possible alternative explanations for a divergence among rates of return on investment for large corporations. For example, we tested to see whether higher rates of return were associated with higher risks as captured by the variance in profits over time. In none of the tests run so far has the inclusion of these other considerations negated the importance of the age factor.

The next hypothesis we wish to test is whether firms that conduct a relatively large amount of research and development earn substantially different (i.e., higher) rates of return on plowback, new debt, and new equity. Thus, we want to see whether age, as we define it, is merely a proxy for research and development intensity, whether research and development in-

tensity has an effect on company rates of return independent of the company or the age of its technology, or whether research and development intensity has any effect at all.

In the coming year, we plan to investigate differences in returns from alternative kinds of investment outlays (e.g., capital equipment, research and development, and advertising). We will use time-series data on firms and examine various lag formulations and interactions among these outlays.

Henry G. Grabowski
Dennis C. Mueller

Firm and Industry Variables as Determinants of Profits

In September 1972 a study was initiated of the determinants of profit rates. This study utilizes the data developed for our study of diversification, with, however, some important data extensions. Specifically, I have used two bodies of data to distribute a company's activities (as measured by employment) by four-digit SIC industries. The two data banks are those of Dun and Bradstreet and of Economic Information Systems. Each of these data banks has information gaps for some firms but is relatively complete for others. From the two, I have been able to develop a sample of roughly 500 firms for which financial data are available from Compustat and for which our information on the configuration of SIC activities seems reasonably complete. This sample will shortly be expanded further by extracting information for individual companies from both data banks. Both sets of data are incomplete for numerous firms, but the information from the two sets is frequently complementary rather than overlapping. This enables one to derive fairly complete information for companies for which both sources, taken separately, are seriously incomplete.

My first problem is to measure profit rates for "homogeneous" industries as distinct from the customary averages based on the classification of firms in particular industries regardless of how diversified the activities of the firms may be. My next step will be to assess if there is significantly less dispersion in profit rates within industries than for the population of firms, and whether

there is more or less stability over time in the ranking by profit rates of firms than of industries. Finally, I propose to develop and test a predictive model for firm profit rates using variables that pertain both to the characteristics of industries and of individual firms.

Michael Gort

Diversification, Mergers, and the Growth of Large Companies

I intend to extend the scope of this study to include an assessment of recent evidence on the relationship between diversification and profitability. Included will be a regression analysis of the impact of diversification on profitability at the micro level using recent data.

I will augment the cross-sectional analysis of the sample of large companies over the 1954–58 period (described in detail in last year's *Annual Report*) with a discussion of the 1958–67 trends in diversification revealed by recent Enterprise Statistics Publications.

The target date for the completion of this study is September 1973.

Thomas A. Wilson

Marketing and Advertising Studies

The principal activity on this project during the past year was the expansion and refinement of basic data sets on advertising and related decision variables. Data at the industry, firm, and brand levels now have been collected for many consumer-oriented industries. These data are being used to analyze the effects of advertising on various firm and industry performance measures (e.g., market shares, sales, and profit rates). As previously reported, distributed lag models of the effects of advertising have been estimated in the cereals, gasoline, beer, liquor, soft drinks, and cigarette industries. Additional industries will be analyzed in this manner during the coming year. In addition, more involved and sophisticated models of the determinants and effects of advertising will be estimated for cases in which data availability makes this procedure feasible. These extended models will analyze advertising in an interdependent context with other decision variables of a firm and its rivals. This research is being supported, in part, by funds from the American Association of Advertising Agencies.

Henry G. Grabowski

Railroad Productivity

The evolution of the economy—the changing composition of industrial activity and the changing spatial patterns of production and consumption—have substantially altered the demand for intercity freight transportation. In the railroad productivity study, we are deriving what implications such changes may have on the demand for rail service. There has been a tendency over the past decades to attribute the stagnation in rail traffic to competitive means of transportation. Although the railroads have been "out-competed" for some of the traffic they have lost, the changing character of freight traffic has also contributed to the decline in the rails' share of the total market.

Despite the changing nature of the market it serves, the railroad industry has tended to cling to traditional forms of service. In so doing, the productivity of primary factor inputs to the industry, it would seem, has not risen so much as it might have if rail service had evolved in conformity with the freight market. Hence the low rate of profit in the rail industry.

As if to dispute this surmise, frequently cited statistics, published by the U.S. Bureau of Labor Statistics, show that labor productivity in the rail industry, measured as gross ton-miles per man-hour, has risen at an annual rate of 5.7 per cent during the period 1947–70, nearly twice the average rate of labor-productivity growth in the private non-farm economy during the postwar period. We believe that the substitution of capital for labor, and other changes in the rail industry, may explain why the measure, gross ton-mile per man-hour, overstates the growth of total factor productivity in this industry, and by correcting for these changes we hope to approach a more realistic estimate of that growth rate.

John R. Meyer
Alexander L. Morton

The Economics of the Performing Arts

This research was initiated at the request of the Ford Foundation for an analysis of the present financial situation of the non-profit live performing arts and an estimate of their future needs. I was released from other National Bureau duties to join a Ford Foundation group working on this project. The product of this research will be included in a report to be published by the Foundation.

The basic problem confronting the performing arts seems to be their inability to cover total expenses by earned income and their dependence on contributed income for survival. This "earnings" or "income gap" is being measured for the years 1965 to 1971, utilizing detailed income and expense accounts of some 180 non-profit symphony orchestras, opera companies, theaters, and ballet and modern dance companies with budgets of $100,000 and over. Considerable data problems have arisen owing to inconsistencies in reporting the figures and to missing information. In order to avoid too large an attrition of the sample, missing observations have had to be filled in and the figures have had to be reconciled before any analysis could be made.

The first stage of the analysis includes an econometric estimate of some crucial parameters such as the price elasticity of demand, the determinants of services income, and the effects of wage raises and changes in the length of season. Preliminary cross-sectional results lead me to believe that a reasonably good estimate of these relationships will be achieved, in which case a simulation model can be used for estimating, in a second stage, future financial needs.

The main argument for adopting simulation techniques is that by estimating the parameters, I will be able to introduce hypothetical issues and trace their final effects on income and expenses through all the estimated interrelationships. Specifically, I would like to be able to measure the impact of reversals such as an increase in unit wage costs, an attrition of contributed income, and a doubling of ticket prices. So-called "Monte Carlo" techniques are being considered as a possible sensitivity analysis.

Guy Herregat

5. INTERNATIONAL STUDIES

Introduction

In its international studies the National Bureau has aimed at developing new tools and data needed for economic analysis and at examining problems of current policy importance. To a large extent, that aim is being achieved with the completion or near completion of several studies and the continuation of others on a variety of topics reported on in further detail by their authors in the reports that follow.

One of these studies scheduled for early publication is that by Mikesell and Furth on foreign holdings of dollars and, more broadly, the role of the dollar in international trade and finance. Despite the recent vicissitudes of the dollar in foreign exchange markets, they see little likelihood that it will be displaced as the leading international medium of exchange.

Another study nearing completion is Garvy's work on money, banking, and credit in the So-viet Union—a topic that, as explained by the author, is secondary to other features of a command economy of the Soviet type but that, nevertheless, is likely to be of growing interest to the United States in view of the prospective development of trade relations between the two countries. Nor should we assume that the financial reforms instituted in 1965, although of limited importance so far, exclude a more significant role for financial policy and mechanisms as the Soviet economy increases in complexity and as its exchanges with other countries expand.

In terms of its potential contribution to more effective use of scarce resources, one of the most important of the Bureau's research projects, and certainly one of the most ambitious in terms of the research effort deployed, is that directed by Bhagwati and Krueger on the exchange control policies and problems of less-developed countries. This project, taking form

in ten country studies by leading development economists and a general synthesis by the co-directors, is particularly timely in view of a certain discouragement observable with regard to development problems and prospects and the need for a better understanding of the relation between internal and external factors in the development process.

Ongoing studies in the international studies area include the research by Kravis and Lipsey on the role of prices in determining levels and changes in the flow of trade, which proceeds out of their earlier basic work in developing reliable measures of prices and price movements. Lipsey and Weiss have continued to probe the connection between U.S. direct investments abroad and U.S. exports, and Kravis and Lipsey are beginning to extend the investigation to the effects of foreign direct investments on the host countries.

These questions relate closely, of course, to the currently much discussed role of the multinational firm and the part it plays in the transfer of technology. A related topic in the area of technological diffusion, although focused on comparative rates of adoption of technological innovations within developed countries, is treated in the series of studies shortly to be published as a product of the research effort in which the National Bureau, represented by Meyer and Herregat, has collaborated with several European research institutes.

Hal B. Lary

Foreign Dollar Balances and the International Role of the Dollar

Our manuscript on this subject is now in press. Although international monetary relations have altered drastically since the study was undertaken, the original aims and coverage remain relevant to the evolving world financial and payments system. Our analysis includes not only liquid dollar claims and liabilities of foreigners vis-à-vis financial institutions and other residents of the United States (American dollars) but also dollar-denominated claims and liabilities among nonresidents (Eurodollars), which have played a major role in recent international capital flows and exchange rate developments.

One interesting result of our statistical analysis is that the major part of fluctuations in U.S. liquid liabilities to "foreign" commercial banks concerned intra-multinational bank obligations; i.e., obligations of U.S. parent banks to their foreign branches and of American branches and agencies of foreign banks to their head offices and branches abroad. Setting aside these liabilities and also those to foreign central banks, foreign holdings of American dollar balances related to the transactions and precautionary functions in financing international trade have shown only a modest growth compared with the rise in international trade itself. It is possible that the growth of multinational banks and of other multinational corporations has reduced the demand, relatively speaking, for foreign dollar balances of the traditional type. In addition, it seems that the growth of Eurodollar deposits has provided a substitute for unofficial short-term deposits in the United States.

Another result is evidence for the decisive role the Eurodollar market played in determining both the gross and the net size of foreign liquid dollar holdings, and especially those of foreign private nonbanks. At the end 1971, about four-fifths of all liquid dollar assets of such holders consisted of Eurodollar balances. Even more important, although foreign borrowing from banks in the United States showed little change, obviously as a result of the U.S. "voluntary" foreign credit restraint program, foreign private nonbank borrowing from Eurodollar banks rose rapidly, especially in 1970 and 1971, when U.S. banks repaid their earlier Eurodollar borrowings. At the same time, the *net* Eurodollar position of foreign private nonbanks shifted from a credit balance of over $6 billion at the end of 1969 to a debit balance of over $10 billion at the end of 1971. This change indicates that foreign private nonbanks converted in 1970–71, directly or indirectly, nearly $17 billion into foreign currencies, accounting for about one-half of the increase in foreign official American dollar holdings in that period, and thus played a decisive role in precipitating the "dollar crisis" of August 1971.

Our general view is that, in spite of the series of crises that have recently afflicted the dollar, the functions it performs in the world economy

may make it difficult, if not impossible, to replace and may impose a barrier to efforts to make the dollar symmetrical with other major currencies in the world payments system.

Raymond F. Mikesell
J. Herbert Furth

Money, Financial Flows, and Credit in the Soviet Union

My manuscript on this subject has been further revised and is in the hands of the editor preparatory to submission to the Board of Directors.

In addition to a detailed examination of the origins and characteristics of the "standard" monetary and credit system, the study devotes special attention to the reforms undertaken in the Soviet Union in 1965. Although these reforms represented the first change of any significance in Soviet economic policy since the launching of the first Five-Year Plan in 1928, the study finds that they were only a half-hearted attempt to deal with some of the most obvious shortcomings of the command economy without changing its basic character. The innovations made did not substitute pecuniary processes for administrative allocations, but did call for a limited restructuring of the price system by explicitly recognizing the cost of capital as one of the elements of production costs, by partially rechanneling financial flows, and by offering inducements to better personal performance by making compensation more dependent on profits achieved. The limited changes along these lines in the Soviet Union, however, fell far short of the steps toward a socialist market economy taken by some of the smaller Eastern European countries in recent years. It remains to be seen whether the Soviet Union will, in time, introduce more imaginative and flexible policies.

Some material included in the original draft of the study has been published in expanded form in two articles: "The Origins of Lenin's Views on the Role of Banks in the Socialist Transformation of Society," *The History of Political Economy* (Spring 1972), and "Banking under the Tsars and the Soviets," *Journal of Economic History* (December 1972).

George Garvy

Foreign Trade Regimes and Economic Development

This project, on which work has been proceeding over the past 3 years under a contract with the Agency for International Development, is now nearing completion. It will include ten country studies and an overall synthesis for which we have primary responsibility as co-directors of the project. A further stage is now envisaged, however, in the form of follow-up conferences in Latin America, Asia, and possibly Africa, with additional financing by AID, to make the results of the research more widely known.

For each of the countries studied the authors were asked to examine: (1) when and why exchange control was adopted, and how the control regime was intended to relate to the country's domestic economic goals; (2) the evolution of quantitative restrictions (QR's) after their initial imposition; (3) efforts, if any, to ameliorate the undesirable results of the payments regime; (4) experiences with attempts to liberalize the regime and the nature and timing of the economy's response to those attempts; and (5) the resource-allocational, income-distributional, and growth effects of the country's experience. Within that framework, each country author singled out a particular point in time for an in-depth analysis of the exchange control regime and selected one liberalization effort for special study.

On the basis of the results so far from the individual studies, we have found a surprising consistency in the conclusions emerging from seemingly diverse situations and experiences. Certainly one of the observations that can be made with some confidence is that, once a regime of quantitative restrictions is established, it seems to create a self-perpetuating force of its own, including the economic and bureaucratic interests developed under the system. The project, therefore, seeks to explore, among other things, the determinants of successful liberalization and the reasons why efforts in this direction are so frequently followed by a relapse into quantitative controls.

Of the individual country studies, the ones on Turkey by Anne Krueger and on Ghana by Clark Leith have been delivered to the publisher.

The next studies expected to be completed are those on India by Jagdish Bhagwati and T. N. Srinivasan; on Egypt by Bent Hansen and Karim Nashashibi; and on Israel by Michael Michaely. Later in the year will follow the studies on South Korea by Charles Frank, Larry Westphal, and Kim Kwang Suk; on Chile by Jere Behrman; on the Philippines by Robert Baldwin; on Colombia by Carlos Diaz-Alejandro; and on Brazil by Albert Fishlow. The overall Bhagwati-Krueger volume should be completed by the end of 1973. All eleven volumes are therefore expected to be published in the latter part of 1973 or the early part of 1974.

Jagdish N. Bhagwati
Anne O. Krueger

The Role of Prices in International Trade

Most of our effort during the past year has been devoted to assembling the data required for our analysis of the role that prices and price changes play in determining export shares and changes in them.

Starting from the price indexes compiled for the volume on *Price Competitiveness in World Trade,* published in 1971, we have now calculated the best approximations we can make to annual international price and price competitiveness indexes for 1953 through 1971 for the United States, the United Kingdom, Germany, and Japan, covering metals, machinery, and transport equipment. We interpolated and extrapolated our original indexes with published export price data from Germany and Japan, the new BLS series on U.S. export prices, and, if these were not available, with various wholesale price and other series. We have also constructed comparable indexes (with the same weighting) from official export price data for Germany and Japan and from wholesale prices for all four countries. For each country and each type of data we have calculated price indexes based on world trade weights and indexes based on each country's own export weights.

In addition to the price data, we have assembled the corresponding annual export data subdivided into three- and four-digit SITC

groups and into ten destinations. For each of the four exporting countries, for each SITC group, we have also collected data to construct two other measures, one for use in cross-sectional comparisons and one for use in time-series analyses. For cross-sections, in which we compare relative exports (say, UK/US) with relative price levels across commodities, we have calculated the weighted average distance of each exporting country from the markets for each commodity. The size of each market, of which there are about 200, is measured by its total imports of that commodity. For time-series studies, we have calculated income change in markets, weighting each market by the size of base-year exports of that commodity to that market by that exporting country.

Our plans for the study include an examination of the effects on exports of not only export price movements but also changes in export prices relative to domestic prices, relative export price levels (in addition to price changes), market shares, and differences among exporters in the average rates of growth of their markets.

Our studies of the measurement of prices and their role in trade have been supported by grants from the National Science Foundation. Marianne Rey, Kurt Kendis, and Barbara Rotenberg have been responsible for collecting data and programming during the past year.

Irving B. Kravis
Robert E. Lipsey

The Relation of U.S. Manufacturing Abroad to U.S. Exports

Several papers have been published so far on various aspects of this study. The first was "The Relation of U.S. Manufacturing Abroad to U.S. Exports: A Framework for Analysis," which outlined the main plans for the study and topics to be covered. The second, "Estimating the Structure of International Transport Costs," developed a method of estimating transport cost for shipments of any product between any pair of countries. The third, "Analyzing Direct Investment and Trade at the Company Level," gave the first substantive results from the study.

These still preliminary results suggest that,

given the size of a country, the more U.S.-owned manufacturing affiliates are located in it, and the larger they are, the smaller will be the country's imports from exporters other than the United States. The relation of these U.S.-owned affiliates to the host country's imports from the U.S. is less clear at this point, presumably because there are both positive and negative influences at work.

Among individual U.S. parent firms, once we took account of their size, exports from the United States to the world as a whole tended to be smaller for firms whose overseas manufacturing operations were larger. Worldwide exports also tended to be lower for firms whose rivals (U.S. firms in the same industry) had larger overseas operations.

We have recently finished a paper on the estimation of transport costs and plan an article giving a more extensive analysis of interrelations between overseas manufacturing and exports.

The research on direct investment and trade has been partly supported by grants from the Ford Foundation and the National Science Foundation. Marianne Rey and Barbara Rotenberg have assisted us in collecting data and programming during the past year.

Robert E. Lipsey
Merle Yahr Weiss

Effects of Direct Investment on Recipient Countries

With the aid of a grant from the Ford Foundation and in cooperation with the Wharton School's Multinational Enterprise Unit, we have begun to explore the possibilities for studying the impact of direct investment on the receiving countries. The work will draw to some extent on the data gathered for the study of the relation of direct investment to U.S. exports but will be focused on the host countries rather than on the United States.

Our initial experiments have been directed toward the question of factor proportions in overseas production by U.S. firms. We are asking whether affiliates of U.S. firms adapt their use of the factors of production, as summarized

in their capital-labor ratios, to relative factor prices in the countries in which they operate. Another question is whether they differ from locally owned firms with respect to their factor use, as might be expected if the affiliates' capital costs are lower than those of native firms.

We hope to extend our investigations to broader aspects of the technological characteristics of multinational firms, asking whether these characteristics of the parent firms account for the extent and nature of their investments and for the type of trade that takes place between parents and affiliates and between the United States and host countries. Beyond that question, we would also like to investigate the degree to which parent firm technology is transferred to host countries, both to affiliates located there and, by purchasing activities, competition and the turnover of native personnel, to native firms as well.

Irving B. Kravis
Robert E. Lipsey

The Diffusion of New Technologies

Work has been completed on the joint project in which the National Bureau has been collaborating over the last several years with several European research institutes aimed at explaining comparative rates of adoption of certain major technological innovations. The particular innovations studied and the research bodies primarily responsible for each one are as follows:

Special presses in paper making
   Industriens Utredningsinstitut, Stockholm

Shuttleless looms in textiles
   National Institute of Economic and Social Research, London

Continuous casting in steelmaking
   Österreichisches Institut für Wirtschaftsforschung, Vienna

Numerically controlled machine tools
   IFO-Institut für Wirtschaftsforschung, Munich

Tunnel kilns in brickmaking
   Istituto Nazionale per lo Studio della Congiuntura, Rome

Basic oxygen process
National Bureau of Economic Research, New York

Publication by the National Institute of Economic and Social Research in London and the Industriens Utredningsinstitut of Stockholm of all the studies in a joint volume is expected later this year.

John R. Meyer
Guy Herregat

6. MEASUREMENT METHODS AND OPERATIONS

Research on Computer-Based Quantitative Methods

Introduction

The broad purpose of the NBER Computer Research Center for Economics and Management Science involves creating a national laboratory for research on computer-based quantitative methods. The following reports specify progress and plans in the various research and support projects at the Center; accordingly, I will restrict myself here to general characteristics and objectives.

The Center is now fully staffed with 45 individuals (33½ full-time equivalents). Eighteen researchers are engaged in two major projects, in the areas of statistical data analysis and mathematical programming, and in a number of smaller efforts. Thirteen programmers, divided into two groups, are developing application subsystems specified by the researchers and are creating an operating system (support environment) for the application subsystems. A six-man support staff is responsible for documentation and consultation. There are also eight administrative and secretarial personnel.

The major subsystems under development are for statistical data analysis and mathematical programming. Each subsystem is being programmed for primarily interactive use on a time-shared computer. Each will effectively provide a laboratory environment for algorithmic research both at the Center and throughout the country.

A prototype mathematical programming system began operating in the summer of 1973, and a state-of-the-art system—primarily for linear programming applications—will be completed in the first quarter of 1974. Research on integer and mixed-integer programming will continue to be a major interest at the Center.

Research on other important mathematical programming problems, especially non-linear programming, will also be started.

A prototype statistical research system has been designed and will be in operation by September 1973. It will provide the mathematical operators and data-manipulation facilities (including facilities for handling n-dimensional arrays) that we need in order to program several subproblems; e.g., robust estimation and estimation of simultaneous equation systems.

Despite obvious differences between statistical data analysis and mathematical programming, they share a mathematical foundation—the problem of optimizing an objective function that is often subject to constraints and is often non-linear. A direct transfer arises in one instance: linear programming turns out to be an efficient device for doing mean absolute deviation minimization, which is one type of robust regression estimation procedure.

Daily operations at the Center are characterized by extremely close contact between programmers and researchers. The development of an effective experimental algorithmic laboratory depends crucially on programmers' responsiveness to research needs. All application programming reflects the closest guidance from the research staff.

Dissemination of the Center's systems will primarily depend on linking our computer facility (currently located at Yale University) with a national data-communication network. The NBER has organized a new entity within itself—the Computer Operations Activity (COA)—which has arranged a network link (to become operational in September 1973), and which will have general responsibility for managing all computer usage by the Bureau.

Although a new venture in itself, the COA

represents a continuation of the NBER's traditional concern for disseminating new methods to the research community. Once a new software product has been properly tested and documented by the Center, it will be turned over to the COA for dissemination and maintenance. Thus, the lag between the development of new techniques and their widespread availability will be shortened, and the efficient operation of the Center as a truly national resource will be ensured.

Edwin Kuh

Statistical Data Analysis

The term "data analysis" has become associated in the past few years with a movement in the statistics profession aimed primarily at reorienting statistical theory to face the realities of empirical data. The acknowledged leaders of this movement are John Tukey (1970–71)[1] of Princeton University and his students. The central themes of data analysis are that a body of data should be met on its own terms and that sensitive as well as sensible tools are required to extract the messages from the data. The data analysis project at the Center is committed to applying this point of view to the problem of empirical research in economics and management science.

The project is conducting research in two broad areas: (1) resistant techniques for fitting linear models, and (2) the analysis of discrete multivariate data. Our work in these areas is discussed in the following paragraphs.

Resistant Techniques for Fitting Linear Models. Linear models play important explicit and implicit roles in the analysis of multivariate data and also provide a flexible framework for describing substantive theories in such fields as economics and sociology. Examples of linear models include multiple regression, the analysis of variance and covariance, and systems of linear stochastic equations. Rather than concentrating on the multivariate-normal and least squares theories of these models, we are exploring areas that we believe are of more urgent practical importance: the impact of recent de-

velopments' in robust estimation and multiparameter Bayesian methods.

Generally speaking, robust methods of estimation, unlike more standard estimation procedures, are not adversely affected by moderate departures from the basic model—e.g., a few wild or contaminated data values or moderate changes in the shape of the underlying distribution. Recent research (Andrews *et al.* [1972], Hoaglin [1971], Huber [1972]) has concentrated on a comparatively simple situation—estimating location and scale parameters in the symmetric univariate model. These problems are becoming well enough understood that we are beginning to transfer our insights to multivariate situations such as regression and the analysis of variance.

During the fall of 1972, David Hoaglin, Roy Welsch, and I studied previous work on robustness to see what might be usefully generalized to multiple regression problems. We concentrated primarily on understanding *M*-estimators as described in Huber (1972). One output of this effort was an experimental program, built from facilities available in TROLL, for a form of robust regression. Convergence problems with this program led to several fruitful discussions with the Center's numerical analyst, Virginia Klema, and a visiting analyst, James Douglas, from the University of Chicago.

During the spring of 1973, Hoaglin taught a graduate seminar on robust estimation at Harvard University, which provides a continuing focus for our work on robust regression.

Bayesian methods have been applied to many problems in statistics, but one of the most successful applications has been in estimating a large number of parameters. The "simultaneous estimation problem," as it is sometimes called, is now receiving greater attention (Efron and Morris [1972], Lindley [1971], Fienberg and Holland [1972]). It needs even more attention in the estimation of simultaneous equation systems, in which a multitude of parameters often are involved. Theoretical work goes back to James and Stein (1961). The estimators that are emerging from this line of research are neo-Bayesian in character, and the improvement in estimation over "least squares" can be substantial if a large number of estimated parameters must be dealt with. Since the original work,

much research has been done on related problems for more general models. We intend to build on these results to produce new or modified data-analytic tools that are sensitive to the problems of estimating many parameters.

An important pilot study on the effectiveness of various competitors to ordinary least squares estimation in regression has recently been completed by Dr. Nanny Wermuth (1972), under the direction of Professor Arthur Dempster, at the Department of Statistics, Harvard University. This Monte Carlo simulation study compared over fifty regression methods for the simplest multiple regression problem; the study suggests that some simple neo-Bayesian estimators are a consistent improvement over ordinary least squares and deal effectively with the problem of multicollinearity. We expect to pursue this type of simulation study, extending it to study the effects of outliers and complex autocorrelation structures.

One problem we considered in the fall of 1972 was whether or not there was a reasonable way to successfully mix robust and neo-Bayesian regression methods. We have been exploring the following approach to this problem. In regression we distinguish the "fitted values" (i.e., y) from the "parameter estimates" (i.e., β). Robust regression methods are really concerned with providing values of y that are not unduly sensitive to the effects of only a few observations. The successful neo-Bayesian methods, on the other hand, concentrate on β and provide estimates that are more accurate than the corresponding least squares estimators. Traditional econometric practice using least squares intermixes the problems of finding y and β (under the guise of providing a simple solution to both problems), but it seems to us from what we now know that they should be separated. We will continue to investigate this approach to multiple regression problems to see if it may provide more meaningful data-analysis tools than we now have.

Analysis of Discrete Multivariate Data. A rapidly growing number of statistical studies on the analysis of multidimensional contingency tables is beginning to filter into many disciplines —e.g., sociology, biology, history, and medicine. The central tools in this development are a variety of ways of fitting log-linear models to the cell frequencies of multidimensional tables. I am now collaborating on a book aimed at making this technology accessible and understandable to a wide audience.

We had originally planned to develop at the Center an interactive program to perform log-linear analyses of multidimensional contingency tables. However, we soon realized that a "statistical language" for manipulating n-dimensional arrays would, if properly done, provide an easy environment in which to write the log-linear analysis program; in addition, it would give the data-analysis researchers an extremely useful tool for solving many other types of problems that arise in our work. Hence, we have been working with the Center's programming staff— primarily Mark Eisner and Richard Hill—to design such a language and the supporting software system. The language is tentatively named DASEL (for Data Analysis Statistical Experimental Language).

When the interactive log-linear analysis program is available, it will allow us to explore the problems currently being investigated by research economists and to ascertain the extent to which this approach can help solve them. This approach, in turn, will suggest directions in which the technology needs to be extended. We have found two Center-related projects that may benefit from the log-linear model technology. John Meyer has a six-dimensional table of data on the development of new businesses and their mobility. John Kain and William Apgar are faced with the "inverse problem"; i.e., they know some of the two-dimensional faces of a five-dimensional table and want to fill in the entire table as best they can, based on this margin information. The same technology can be used to attack both of these problems, and this flexibility is one of the appealing features of the log-linear approach to discrete multivariate data.

Paul W. Holland

Mathematical Programming

The Center's mathematical programming project will continue, for the next year, to develop

a software package for large-scale linear and mixed integer programming. Complementary activities in which we will also be involved include experimentation with new computational methods of integer programming and discrete optimization, problem formulation and solving in diverse applications areas, and fundamental research in discrete optimization and large-scale optimization.

The linear programming module of our mathematical programming system is progressing well, and the first version of it should be completed during the first quarter of 1974. This work is being performed by William Orchard-Hays, Michael Harrison, and William Northup. Most of the important subroutines have been written and are being debugged. These include the general input and setup procedures, simplex algorithms, and output procedures. A serviceable inversion procedure is in the coding stage.

The main task in the coming months will be to encode a more efficient matrix inversion routine for large models, to be used by the simplex algorithms, and additional service modules to facilitate computational continuity and flexibility. There are many different methods for matrix inversion, and the relation of these methods to special problem structure remains an important research question in large-scale linear programming. Virginia Klema and Tom Magnanti will be involved in studying new methods of matrix inversion. The interesting nature of this system also creates new service concepts. Thus, we envision a continuing evolution of our linear programming module beyond the first completed version because we will be gaining more insight into both matrix-inversion theory and a new operational environment.

The linear programming module, once completed, will serve as a building block for our mixed integer programming algorithms. One approach to mixed integer programming is to solve a series of related linear programming subproblems, derived from a given mixed integer programming problem, by fixing the integer variables. This approach has been found to work well for those problems in which many or most settings of the integer variables produce feasible linear programming subproblems. For example, consider the problem of where to locate factories at least cost in a nationwide production/distribution system if there are no capacity restrictions on new factories. (Any solution is feasible except the one in which no factory is built.) In this example, the linear programming subproblems are the production and distribution subproblems that result if the factory locations already have been selected.

Other classes of integer programming problems cannot be solved in this way. In particular, pure integer programming problems are combinatorial or number-theoretic in nature, and it is not possible to fix some of the decision variables to produce more easily solved linear programming subproblems. Such problems arise, for example, in capital budgeting, airline-crew scheduling, and optimal design of communication networks. We have been experimenting with new methods of pure integer programming that exploit the number-theoretic structure of these problems. These methods have proven effective for pure integer problems, such as the ones just mentioned, and we anticipate more success with them when we incorporate them into our production mathematical programming system.

Our experimental pure integer programming algorithm has recently been installed at the Center, and we are in the process of making it available to researchers in universities and industry. This work is being performed by Bill Northup and Jeremy Shapiro. We are also seeking to develop a classification for mixed integer programming and discrete optimization problems in order to integrate diverse methods and apply the most effective methods to a given problem. Marshall Fisher, visiting from the University of Chicago, is active in this aspect of our research.

Finally, we have started to consider non-linear programming algorithms and applications, the latter particularly in the areas of robust estimation and constrained non-linear regression. For these purposes we are currently using the SUMT non-linear programming code developed by Fiacco and McCormick.

Jeremy F. Shapiro

Estimation of Equation Systems

The initial aim of our work is to design and program interrelated software modules that will en-

able a researcher to use and compare the more important estimation techniques—specifically, simultaneous system estimators. The availability of such a facility is a prelude to experimentation with, and systematic comparison of, the estimators. We now know very little about the small-sample properties of these estimators; the projected software modules will provide, for the first time, a means of amassing the experimental evidence required to compare the estimators properly.

The estimation techniques to be included are:

1. Double k-class
   a. Two-stage least squares (2SLS)
   b. Limited information maximum likelihood (LIML)
   c. Unbiased k to order $T^{-1}(UKT^{-1})$
   d. Nagar minimum moment estimator (MM)
   e. General double k-class ($k_1 k_2$)

2. Three-stage least squares (3SLS)

3. Instrumental variables (IV) (Brundy and Jorgenson, 1972; Hausman, 1972)
   a. General IV
   b. Limited information IV (LIVE)
   c. Full information IV (FIVE)

4. Full information maximum likelihood (FIML)
   a. Non-linear FIML (Chow, 1972)
   b. Iterative FIVE (Hausman, 1972)

In each case estimators are being developed to handle both linear and non-linear equations.

The basic modules for the double k-class and 3SLS estimators have been designed. The design draws heavily on a study by Ruble (1968). Computational problems encountered with these estimators are being studied by the Center's numerical analysts, Virginia Klema and Donald Rose. Programming of these modules should commence shortly.

The Brundy–Jorgenson limited and full information instrumental variable estimators are currently being adapted for our purposes.

A generalized FIML routine is now being designed, with heavy emphasis on the FIML technique for non-linear equations, which Chow (1972) is developing for this purpose. The routine will be specialized to accept a diagonal co-variance matrix of the disturbance terms among the equations. This procedure promises computational advantages with minimum sacrifice of efficiency in real-life situations; it also deals with diagonal second-order Markov schemes in the disturbance terms.

David Belsley (Boston College) and Swarnjit Arora (University of Wisconsin at Milwaukee) now coordinate this project. Phil Cooper (University of Chicago) initiated the project during the first 3 months of 1972 and continues to serve as a consultant.

David A. Belsley

The Shifting Regression Problem

The shifting regression problem deals with the statistical detection and explanation of changes in regression parameters over time. Unstable parameter estimates pervade virtually every area of applied econometric research. For example, if the structure of an inventory-investment model, usually assumed to be unchanging, varies in fact with the cyclical influences of general economic activity, or with a major strike, standard statistical techniques such as least squares will yield incorrect results. Methods for dealing with shifting regressions represent a crucial extension of regression analysis. But to date, little systematic effort has been applied to deriving these techniques.

The econometrics group at the Center is exploring various techniques that have evolved from statistics and optimization theory. Various aspects of testing and estimation in the context of systematic shifts in regression coefficients have been studied (Belsley, 1972a; 1972b). The estimation of time-varying coefficients through the use of the Kalman filter has also been considered (Sarris, 1972). Both of these areas will receive additional attention.

On January 26 the Center sponsored a symposium on the shifting regression problem. At this symposium the research staff of the Center was joined by many of the field's leading researchers, including Professors Stephen Goldfeld (Princeton University), Clifford G. Hildreth (University of Minnesota), Richard E. Quandt (Princeton University), Barr Rosenberg (University of California at Berkeley), and David Duncan (Johns Hopkins University). Papers and reports

were delivered by these individuals, as well as by Belsley and Sarris. Tentative arrangements have been made to publish the symposium papers in the October 1973 issue of the National Bureau's *Annals of Economic and Social Measurement.*

David A. Belsley

Spectral Analysis

Spectral analysis provides a convenient method for discovering recurring regularities in economic and other time series. For example, business cycle or seasonal oscillations can be easily isolated, and leads and lags between time series can be analyzed. The Center has programmed a subsystem that computes and displays spectral and cross-spectral analyses with the associated confidence statistics; the latter indicate what could be expected if the series were purely random.

Spectral analysis is also a useful tool in the regression context. For example, spectral analysis has been used to isolate various frequencies within a regression model (Engle, 1972b). This technique provides a test for misspecification of the model over different frequency components, a solution to the problem of seasonality, and a mechanism for estimating models with errors-in-variables that are concentrated in some frequencies. In a useful application of this procedure (Engle and Foley, 1972), high frequency components of stock-market series were eliminated as having a large noise or error component. The Center has programmed a facility for computing band-spectrum regressions.

Another application of spectral analysis in regression is to test and correct for serial correlation without specifying the order of the process. A general test against all orders of serial correlation (as opposed to merely first order, as in the Durbin–Watson test) has been proposed by Durbin (1969). This test is now available. Spectral analysis can also provide a method for efficiently estimating a model with serial correlation of an arbitrary order. This estimator, proposed by Hannan (1963), has not been used in practice because the computations are laborious and because the finite sample properties are suspected of being far inferior to the asymptotic

properties. The computational problems have been overcome in the Center's subsystem, and the estimator is soon to be available for general use.

It is important to examine the finite sample properties; low-order approximations of the actual process of the serial correlation may be not only inefficient but even less efficient than ordinary least squares (Engle, 1972a). To evaluate the finite sample properties of Hannan's estimator, Roy Gardner of Cornell and I have been undertaking Monte Carlo studies as well as examining analytically the finite sample properties of the estimators.

Robert Engle

Numerical Analysis

Research in numerical analysis is conducted at the Center in the context of the econometrics, data-analysis, and mathematical programming projects. The immediate goals are to improve algorithms for econometric simulation and regression and to experiment with new matrix-inversion methods for linear programming. Much of our work in the econometrics area is initially being tested within TROLL and will later be transferred to the Center's new systems.

For simulation, the solution of the linear system obtained from the linearized model is computed by LU decomposition, based on Cleve Moler's subroutine SOLVE. We use column equilibration—i.e., block-column scaling—because of the nature of the coefficients. Exact power of the machine arithmetic is used such that the model is not distorted, although the choice of pivots will not be altered for partial pivoting. Rich Hill programmed the LU decomposition routines.

In estimation, the unconstrained optimization of an objective function is implicit. The standard Newton's method is central to our consideration. Robust estimation requires the direction of steepest descent, followed by the solution of a linear system of equations. Given rank deficiency, this solution may not be unique, in which event we obtain the solution of minimal norm, which is unique. The simplest yet most complete interpretation of the matrix is exhibited by singular value decomposition. We are utilizing

the singular value decomposition subroutine MINFIT by Golub and Reinsch (1971). This sub-routine is taken from EISPACK, implemented at the Applied Mathematics Division, Argonne National Laboratory; it was extracted from EISPACK by Harry Bochner and will be inserted in the system here by Fred Ciaramaglia.

The computational problems of limited information maximum likelihood are handled by MINFIT. This must be supplemented by methods for modifying (i.e., updating) the matrix factorizations; such methods are provided by Gill, Golub, Murray, and Saunders (1972). Three other subroutines from EISPACK are used to compute extreme eigenvalues.

The modularity of the mathematical programming system facilitates experiments with scaling and alternative methods of matrix factorization. Norm-preserving methods such as those developed by Gill and Murray (1970) and Saunders (1972a; 1972b) will be considered.

Throughout this work we are relying heavily on the advice of Jim Douglas, Jr. (University of Chicago) and Gene Golub (Stanford University). Ken Hillstrom (Argonne National Laboratory) has generously shared his insights into various aspects of least squares solutions and minimizing an objective function. Don Rose (Harvard University) is a regular consultant at the Center. C. L. Lawson and Fred Krogh (both of the Jet Propulsion Laboratory) have provided useful information on singular value decomposition and programs for non-linear least squares.

Virginia C. Klema

Computer Programming

The programming staff has matured over the past year into an integrated support function for the Center's research. The staff is divided into two groups—application programming and system programming—under the overall direction of Gerald Ruderman.

The application programming group is in the process of designing and implementing two large subsystems. One will provide a software laboratory for mathematical programming research. It is being implemented primarily by Bill Northup and Mike Harrison under the guidance of William Orchard–Hays. The other large sub-

system will provide a software laboratory for research on statistical and data analytic methods. This work, which is now in the design stage, is being performed by Rich Hill, Fred Ciaramaglia, and Mark Eisner, in close cooperation with Paul Holland of the research staff. Harry Bochner will join Hill in implementing a prototype system, to be completed by the end of this year.

Smaller application subsystems, which are now close to completion, include the following:

1. A subsystem for spectral analysis of economic and other time series. This subsystem was specified by Professor Robert Engle of Cornell and implemented by Jonathan Shane. (For a further description, see the section on Spectral Analysis.)

2. A subsystem for determining optimal policy, based on strictly linear economic models. This was coded by Dave Boyajian and is available within the TROLL framework.

3. A prototype interactive graphics package for the analysis of multidimensional data. This package, which was designed and implemented by Helge Bjaaland, is the first exploratory step in using computer graphics for statistical data analysis. Although the package runs on a low-cost storage tube, it includes many features previously available only on expensive display devices.

4. Implementation of state-of-the-art numerical techniques in TROLL. This work, which is being performed by Rich Hill and Fred Ciaramaglia, will facilitate a study of the properties of these new techniques in relation to problems that arise in economic research. Given this information, the techniques are likely to become basic elements in many subsystems written at the Center.

In addition to the above, the application group has provided programming support for experiments with robust estimation techniques, for direct updating of the NBER macroeconomic data base, and for experiments with various existing mathematical programming codes.

The system programming staff is actively engaged in designing and implementing an Application Control Operating System (ACOS). ACOS (referred to in the 1972 *Annual Report* as COS) will be the operating environment for all application subsystems; it will provide support facili-

ties—e.g., data management, error recovery—used by the subsystems. The basic system programming will be done by Dave Anderson and Walt Oney, and Joel Lexier and Annette Somers will be responsible for creating a control interface language called ACOL.

The system programming group has also been involved in a wide variety of smaller projects occasioned by changes in the Center's computer facilities and system environment. Small adjustments had to be made to accommodate the transfer of computer operations from the System/360, Model 67, at MIT to the one at Yale. Furthermore, an elaborate accounting system has been created and installed; this system will enable the Center to keep track of, and appropriately charge for, computer usage by both internal and external users. Finally, the system staff has been involved in preparing for changes in the Center's system environment to accommodate new hardware and software announced by IBM. These changes will make IBM's new System/370 computers similar to the 360/67; therefore, they will greatly enhance the potential for exporting the software systems developed at the Center.

<div align="right">Mark Eisner</div>

Support: System Dissemination and Documentation

Support activities at the Center are devoted to documenting and disseminating software systems and to consulting with researchers on their use. Since our last report, the focus of these activities has gradually shifted from TROLL and experimental subsystems initially implemented under TROLL to application subsystems and ACOS. Developments fall into five major areas: (1) staff growth and organization, (2) documentation of new systems, (3) TROLL documentation, (4) user communities, and (5) computer and communication facilities.

Staff. A technical publications and consulting staff of unusual depth and balance has been formed. Walt Maling, a member of the original MIT TROLL project, continues to serve as the principal consultant to users of the Center's software. Wayne Zafft, Robert Perron, and Gary Solomon have joined the Center as technical

writers. Zafft and Solomon now specialize in user documentation of new application subsystems; Perron works primarily on user and programmer documentation of ACOS. Nancy Burrows, with the assistance of Sandra Temmallo, manages the production and distribution of publications.

Documentation of New Systems. Work has progressed on the documentation of both ACOS and various application subsystems. Preliminary design, implementation, and user specifications of ACOS, and of the related ACOL language, are in preparation. User manuals for experimental matrix-manipulation routines, for the spectral analysis subsystem, and for the optimal control subsystem have been written. Since the matrix-manipulation routines facilitate new applications of TROLL to cross-sectional data, a manual explaining these applications has been prepared. Procedures for creating and maintaining internal specifications of new systems, especially the mathematical programming system, have been developed.

The support group has also helped start a new series of publications, the Center's Research Reports. These are occasional papers by the researchers on various aspects of their work. Arrangements have been made for publishing abstracts of these papers in the *Annals of Economic and Social Measurement.* (The *Annals* has also begun to publish periodic general reports on the Center's research activities.)

TROLL Documentation. Four levels of TROLL user documentation have been defined and written: an overview of capabilities (*TROLL: An Introduction and Demonstration*); a beginning user's manual (*TROLL Primer*); a tutorial guide to an extended subset of capabilities (*TROLL User's Guide*); and an encyclopedic specification of all capabilities (*TROLL Reference Manual*). In addition, two manuals on TROLL's specialized macro programming facilities have been prepared.

Documentation in conventional published formats has been supplemented by "on-line" documentation, which is stored within the system itself and can be selectively printed by the user on his terminal at any time.

User Communities. Communities of researchers who are actively using TROLL and new Cen-

ter software are located in and around Boston, New Haven, New York, Washington, D.C., Ottawa, and Toronto.

In the Boston area, the major communities are at the departments of economics of MIT and Northeastern University, the Harvard Center for Behavioral Sciences, the Transportation Systems Center of the U.S. Department of Transportation, and the U.S. Federal Reserve Bank.

The New York communities center around NBER headquarters, the U.S. Federal Reserve Bank, and the Budget Bureau of the City of New York. The New Haven communities include members of Yale's departments of economics and political science as well as personnel at the NBER's New Haven office. Most of the Washington, D. C. users are researchers at the U.S. Federal Reserve System.

Computer and Communication Facilities. In August 1972 the Center transferred its computing work from the System/360, Model 67, at MIT to the one at Yale. The transfer itself was performed smoothly, but a heavy user load on the Yale machine resulted in slow response and thus hampered system dissemination for several months.

Some progress has been made in developing inexpensive data-communication facilities between the Yale computer and users in the northeastern U.S. The Center itself, as well as the Boston user communities, are served by a multiplexor in Cambridge and by leased lines from Cambridge to New Haven. Other leased lines serve users in New York City, and a WATS line accommodates users anywhere from Virginia to Maine.

More extensive data-communication facilities are needed to support both collaboration between the Center's on-site research staff and associates across the country, and general dissemination of Center systems. To these ends, the NBER's new Computer Operations Activity has arranged a link between the Yale computer and TYMNET, a national data-communications network. This link, which becomes operational in September 1973, will provide users in and around forty cities throughout the U.S., with inexpensive access to the Center's systems.

John Kirsch

Bibliography

(Works cited by author and date on pages 114-119.)

Andrews, D. F., *et al.* (1972), *Robust Estimates of Location: Survey and Advances,* Princeton, New Jersey, Princeton University Press.

Bartels, R. H., and G. H. Golub (1969), "The Simplex Method of Linear Programming Using LU Decomposition," *Communications of the Association for Computing Machinery,* 12, pp. 266-268.

Belsley, D. (1972a), "Note on Shifting Regression," Research Report No. W0005, National Bureau of Economic Research, Computer Research Center for Economics and Management Science.

Belsley, D. (1972b), "A Test for Systematic Variation in Regression Coefficients," Research Report No. W0006, National Bureau of Economic Research, Computer Research Center for Economics and Management Science.

Brundy, J., and D. Jorgenson (1972), "Efficient Estimation of Simultaneous Equations by Instrumental Variables," *Review of Economics and Statistics,* 53, pp. 207-224.

Chow, G. C. (1972), "On the Computation of Full-Information Maximum Likelihood Estimates for Non-Linear Equations Systems," Econometric Research Program Research Memorandum No. 142, Princeton University.

Durbin, J. (1969), "Tests for Serial Correlation in Regression Analysis Based on the Periodogram of Least Squares Residuals," *Biometrica,* 56.

Efron, B., and C. Morris (1972), "Limiting the Risk of Bayes and Empirical Bayes Estimators —Part II: The Empirical Bayes Case," *Journal of the American Statistical Association,* 67, pp. 130-139.

Engle, R. (1972a), "Specification of the Disturbance for Efficient Estimation," *Econometrica,* forthcoming.

Engle, R. (1972b), "Band Spectrum Regressions," *International Economic Review,* forthcoming.

Engle, R., and D. Foley (1972), "A Supply Function Model of Aggregate Investment," Working Paper 89, MIT Department of Economics.

Fienberg, S., and P. Holland (1972), "Simultaneous Estimation of Multinomial Cell Probabilities" (unpublished manuscript).

Gill, P. E., and W. Murray (1970), "A Numerically Stable Form of the Simplex Algorithm," Technical Report No. Maths 87, National Physical Laboratory, Teddington, Middlesex, England.

Gill, P. E., G. H. Golub, W. Murray, and M. A. Saunders (1972), "Methods for Modifying Matrix Factorizations," STAN-CS-72-322, Stanford University.

Golub, G. H., and C. Reinsch (1971), "Singular Value Decomposition and Least Squares Solutions," in J. W. Wilkinson and C. Reinsch (eds.), *Handbook for Automatic Computation, Volume II: Linear Algebra,* New York, Heidelberg, and Berlin, Springer–Verlag.

Hannan, E. J. (1963), "Regression for Time Series," in M. Rosenblatt (ed.), *Proceedings of the Symposium on Time-Series Analysis,* New York, John Wiley.

Hausman, J. (1972), "An Instrumental Variable Interpretation of FIML and Associated Estimations" (unpublished manuscript).

Hoaglin, D. C. (1971), "Optimal Invariant Estimation of Location for Three Distributions and the Invariant Efficiencies of Some other Estimators," unpublished doctoral dissertation, Department of Statistics, Princeton University.

Householder, A. S. (1964), *The Theory of Matrices in Numerical Analysis,* New York, Blaisdell Publishing Company.

Huber, P. J. (1972), "Robust Statistics: A Review," *Annals of Mathematical Statistics,* 43, pp. 1041-1067.

James, W., and C. Stein (1961), "Estimation with Quadratic Loss," in *Proceedings of the Fourth Berkeley Symposium on Mathematical Statistics and Probability,* 1, Berkeley and Los Angeles, University of California Press, pp. 361-379.

Lindley, D. (1971), "The Estimation of Many Parameters," in V. P. Godambe and D. A. Sprott (eds.), *Foundations of Statistical Inference,* Toronto, Holt, Rinehart, and Winston, pp. 435-455.

Ruble, W. L. (1968), "Improving the Computation of Simultaneous Stochastic Linear Equations Estimates," Agricultural Economics Report No. 116, Michigan State University.

Sarris, A. (1972), "A Bayesian Approach to Estimation of Time-Varying Coefficients," Research Report No. W0007, National Bureau of Economic Research, Computer Research Center for Economics and Management Science.

Saunders, M. A. (1972a), "Large-Scale Linear Programming Using the Cholesky Factorization," STAN-C5-72-252, Stanford University

Saunders, M. A. (1972b), "Product Form of the Cholesky Factorization for Large-Scale Linear Programming," STAN-C5-72-301, Stanford University.

Tukey, J. W. (1970–71), *Exploratory Data Analysis,* Limited Preliminary Edition, Volumes I-III, Reading, Massachusetts, Addison–Wesley.

Wermuth, N. E. (1972), "An Empirical Comparison of Regression Methods," unpublished doctoral dissertation, Department of Statistics, Harvard University.

Other Computer-Oriented Activities

Electronic Data Processing for Research Support

Unlike the Computer Research Center operations, which focus on the development of new computer-based statistical methodology, the data processing operations at the National Bureau's New York office support primarily the economic research of staff members.

Our operations are currently undergoing a major technological revamping. We are abandoning our small in-house IBM 1130, whose capability we had stretched beyond its intended purpose. The new equipment will mainly consist of several terminals linked to the 360/67 at Yale, the 360/91 at Columbia, and several time-sharing systems. Furthermore, we will have a large terminal with a high-speed card reader and printer that will also have access to Yale's 370/155. This arrangement will make it possible for us to handle large data sets and large data-handling jobs with relative ease via "Remote Job Entry." At the same time, it will permit us to handle smaller jobs interactively on a time-sharing basis. We intend to use a terminal with a cathode-ray-tube display system for produc-

ing working charts and for designing final charts to be executed on a remote large Calcomp flat-bed plotter.

The support functions of the unit consist largely in providing and adapting programs for the use of researchers and in assisting the staff in all phases of their data-processing operations. Some of the current programming work involves adapting our program library to the available hardware. This is being done primarily by Tere-sita Rodriguez and Antonette Delak. Martha Lichtenstein, who has been concerned with scheduling and maintenance of the IBM 1130, will perform these tasks for the various termi-nals. Another major claim on the time of the unit's programmers, mainly of Susan Crayne and Phyllis Goldberg, consists in handling large-scale data sets on magnetic tapes. In fact, input and output of magnetic tapes has become so important and costly that we found it advis-able to have some of our programmers take a special course to increase the efficiency of these operations.

Our time-series data bank operations con-tinue to grow. They will be described in the fol-lowing report by Josephine Su. Furthermore, there is a virtual explosion of tape-based micro information in the Bureau's tape library, in the libraries of other research organizations and, of course, in the data collections of the various branches of government. Documenting these collections and adequately standardizing the documentation have become increasingly im-portant. I am organizing a continuing workshop on these problems under the auspices of the Bureau's Conference on the Computer in Eco-nomic and Social Research.

While at present our unit is no longer preoc-cupied with the provision of basic general pro-grams and new methodology, some of our past work in these areas is in heavy demand by re-searchers both within and outside the Bureau. Among the more recent programs demanded are the Haitovsky–Jacobs Regression Genera-tion program (REGEN), the Bry–Boschan Turn-ing Point Determination Program (NBTP), and various programs dealing with the cyclical analy-sis of time series.

Charlotte Boschan

NBER Data Bank

Since 1969 the Bureau has maintained a data bank of machine-readable economic time series for internal use by the research staff and for the use of participating outsiders. The data bank was started (1) to avoid duplication of effort in collecting, maintaining, and updating; and (2) to keep these time series in machine-readable form, immediately available for input into com-puter programs.

At present the bank contains some 2,200 monthly, quarterly, or annual time series, includ-ing almost all series shown in the Census Bu-reau's *Business Conditions Digest;* the Council of Economic Advisers' *Economic Indicators;* and the Bureau of Economic Analysis' *National Income and Product Accounts,* as published in the *Survey of Current Business.* Most time series are available in the data bank from 1946 or 1947 on. Because of users' demand for short-term forecasts of some major economic indicators, we recently added the consensus forecasts of the quarterly ASA–NBER Economic Outlook Survey.

The data bank is accessible through several time-sharing systems. After receiving daily re-leases of data source documents through a press service from Washington, paper tape is produced, and the data bank is updated in all participating time-sharing systems within 48 hours. The participating time-sharing systems in this program are Rapidata, General Electric's Information Management and Project System (MAP), and the Service Bureau Corporation. We now have fifty-seven subscribers through these three systems (including three non-paying universities).

We also provide magnetic tapes containing all time series to some time-sharing systems whose needs do not justify daily updating. Up-dated versions of these magnetic tapes are pro-vided about once a quarter. The participating time-sharing systems in this group are TROLL (which will soon be shifting to daily updates), Tymshare, Inc., Cyphernetics Corporation, Na-tional CSS, Time Sharing Resources, and Sci-entific Time Sharing Corporation. The magnetic tape version of the data bank has been provided to universities at minimum charges to cover our

cost. Eleven universities are now using our tapes.

The accuracy and consistency of the data series have always been among our most important concerns. One of the problems related to these goals is the handling of discontinuities of various sorts that frequently occur in economic time series. Since data bank users do not see the original documents, they are at the mercy of those who maintain the data bank. We therefore consider it a serious responsibility to keep the data series consistent and to inform users of changes in sample, method of collection, and revisions. If overlapping segments are sufficiently homogeneous to warrant splicing, the procedure used is fully described.

The financial and labor force statistics are Constance Lim's special areas, Wah-Lee Hsu concentrates on national income and product accounts, and Antonette Delak provides special programs for the data bank.

Josephine Su

Statistical Methodology for Nonperiodic Cycles

Work is continuing on the method of R/S analysis in several directions. A series of papers is being written for the *Annals of Economic and Social Measurement,* the first of which already has appeared.[1] The second and third, respectively, are to be devoted to questions of small-sample statistics and to testing empirical results obtained thus far. These results include both work performed in the United States on NBER material and work performed in France under my supervision, using French material.

A purely mathematical paper has been written with proofs of the basic assertions and various generalizations of the method.

The relationship between long-run cyclical nonperiodic behavior and short-run discontinuities, already investigated in two papers, is being studied further.

Benoit Mandelbrot

---

[1] "Statistical Methodology for Nonperiodic Cycles: from the Covariance to R/S Analysis," *Annals of Economic and Social Measurement,* Vol. 1, No. 3 (July 1972).

Research on Distributed Lags

Research for the extended publication on causal orderings and exogeneity in economic time series referred to in last year's *Annual Report* is still in process, consisting particularly of a deeper analysis of the effects of seasonality in applied work, similar to my previous publications in this area, and of work on the statistical characteristics of economic systems in which some policy variables have been subject to optimizing control.

The paper "Seasonality in Regression," described in last year's report, has been substantially revised and will soon be submitted for publication.

Christopher A. Sims

Annals of Economic and Social Measurement

The second year of the new NBER journal saw articles published that demonstrated both innovation and continuity in the NBER program. Subscriptions have grown steadily, reflecting the expansion of the conference program and an increasing interest in the issues raised by computer research in economic and social measurement. We find some interesting patterns in the articles and notes published during 1972 and 1973.

Several issues have been devoted to specialized topics, resulting in some very stimulating and useful collections. Michael Athans and Gregory Chow organized an interdisciplinary workshop on Stochastic Control Theory under the auspices of the NBER Conference on the Computer in Economic and Social Research and prepared a special issue of the *Annals* devoted to that topic. That October 1972 issue makes these ideas more accessible to both engineers and economists. Similarly, some papers presented at the September 1972 Conference on the Current Population Survey made up the April 1973 special issue on that topic. Another special issue, this one featuring the NBER Computer Research Center program, will contain papers presented at a symposium on the problem of statistical estimation involving time-varying parameters. Edwin Kuh and David A.

Belsley will be primarily responsible for that issue, which is scheduled for September 1973. In each of these cases, introductory articles provide overviews of the contents of the issues and surveys of the current state of the art. We are pleased that the *Annals* can serve as a vehicle for getting these papers out to the research community speedily, and in a convenient format.

Other issues of the *Annals* have been more heterogeneous, reflecting the research underway at the Bureau and reports from related projects. For example, the lead article in the January 1973 issue by Julius Shiskin explores a topic that has been part of the focus of NBER activities since its inception in 1920—the measurement of economic fluctuations. Another piece of research, the "nine author" article on "Criteria for Evaluation of Econometric Models," was the subject of a NBER–NSF seminar. In another instance, several programming software notes on the capabilities and limitations of particular input-output systems displayed enough

unity and consistency to justify putting together the set of papers for the July 1973 issue. It is hoped that these notes will serve as a catalyst for a future workshop on the topic.

During the last year, we introduced two new sections, Conference Notes and NBER Computer Research Center Notes, to provide up-to-date information for interested researchers. The sections on Data Banks and Files and Programming Software Notes will continue to provide evaluations and announcements of developments in these areas.

The Board of Editors, consisting of Phillip Cagan, Donald Farrar, John Meyer, Jacob Mincer, M. I. Nadiri, and Christopher Sims, again aided in the development of editorial policy and the screening of potential articles. Sydney Shulman has served as a liaison with the New York office, and John Kirsch has assumed the responsibility for reporting the NBER Computer Research Center activities in the journal.

Sanford V. Berg