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II

1. ECONOMIC AND SOCIAL PERFORMANCE

Productivity, Employment, and Price Levels

Introduction

The Bureau's current research in this area is focused on price behavior and price measurement, particularly on questions associated with inflation. Other aspects of the causes and effects of inflation are discussed in the sections of this report dealing with the Bureau's monetary studies and financial studies, particularly the project on The Effects of Inflation on Financial Markets.

Several volumes from this program have now appeared or will be published shortly. These include *The Behavior of Industrial Prices,* by George J. Stigler and James K. Kindahl (1970), *Postwar Productivity Trends in the United States,* by John W. Kendrick (1973), and *A Disequilibrium Model of Demand for Factors of Production,* by M. Ishaq Nadiri and Sherwin Rosen (1974). There have also been many journal articles and two papers published by the National Bureau, 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. Two new papers by Fabricant have appeared since last year's report: "Business Instability in Today's Economy," in *Business Problems of the Seventies,* edited by Jules Backman, New York University Press, 1973; and "Perspective on Productivity Research," in *Conference on an Agenda for Economic Research on Productivity,* National Commission on Productivity, U.S. Government Printing Office, 1974. Several

other manuscripts scheduled for early staff or board review are mentioned below. Progress on Fabricant's volume on The Problem of Inflation was interrupted this year by other projects but he expects to resume work on it this summer.

The research reported here was begun under grants from the Sloan Foundation and the Alex C. Walker Educational and Charitable Foundation. More recently the main support has been provided by several grants from the National Science Foundation.

Robert E. Lipsey

The Short-run Behavior of Prices

Two of the planned three parts of my study of the behavior of prices have been completed and circulated. The third part is in progress.

The first, "Changes in the Recession Behavior of Wholesale Prices, the 1920s and Post-World War II," documents the well-known decline in amplitude of cyclical fluctuations in prices up to 1970. The aggregate index of wholesale prices shows a sharp reduction in cyclical amplitude after 1949 and further but smaller reductions thereafter. As compared to the behavior in earlier business cycles, prices in recent cycles have risen less in expansions and declined less or not at all in recessions. In fact, prices actually rose in the later recessions, and in the 1970 recession the rate of increase in prices was slightly higher than in the preceding expansion.

To guard against the spurious effects of changes in the composition and weighting of the aggregate index, the study examines frequency distributions in different cycles for the same set of 1,100-odd individual product prices. In this set there is no change in coverage and no prob-

lem of changes in weighting. The frequency distributions of the difference between recession rates and the preceding expansion rates of these price series show even more clearly than the aggregate index a diminished response from one recession to the next. The entire distributions shift consecutively to higher rates of change. Although a decline in severity of recessions in real terms over the postwar period has undoubtedly contributed to the reduced amplitude of price fluctuations, the decline in severity is not consistently chronological and so does not fully account for the decline in price response. General anticipations of inflation have intensified over the postwar period, which apparently has diminished the response of prices to declines in economic activity. This is in addition to the higher anticipated rate of inflation from which each recession decline begins. The paper gives an interpretation of these developments.

In the second part of the study, "Inflation and Market Structure, 1967–73," I examine the influence of concentration and firm size on prices. Previous studies have found a mixed influence, sometimes positive and sometimes negative. One view has been that giant corporations are an independent source of inflationary pressure because they continually raise their prices relative to costs. Another view is that their prices actually lag behind inflation in the rest of the economy. My study regresses price changes in eighty-six four-digit industries on their unit materials and labor costs and an index of either concentration or firm size. I find that the more concentrated industries and larger firms exhibit a sequential pattern: their prices in relation to costs first lagged behind other industries in 1967–69 and then later started to catch up. This catching up was reflected in larger price increases in relation to costs in 1971 when inflation at large was subsiding. In my report last year of the data through 1970 only, I was puzzled by the absence of such a changeover. When I subsequently examined 1971, the change of direction appeared and clarified the puzzle. The changeover pattern supports the theory that the prices of concentrated industries tend to lag behind in inflationary movements and, if anything, delay the transmission of inflation. The

effect of price controls on large corporations in 1971–73 is also examined.

In the third part of the study I compare the timing of price responses to changes in output in fifteen major industries in two periods of waning inflation, the late 1950s and 1969–71. My purpose is to verify whether prices were slower to reflect the slackening of market demand in the second episode than in the first, and what other differences in the pattern of the inflations were evident. This part should be completed by late 1974.

Phillip Cagan

Behavior of Output and Input Prices

The first phase of the study on behavior of output and input prices has been completed. I have constructed a model to explain the behavior of output prices, wage rates, materials prices, costs of capital and profits in the aggregate economy, the total manufacturing sector, and twelve two-digit manufacturing industries. A large body of data has been collected on a considerable number of explanatory variables, both at the aggregate and industry levels. The quarterly time-series data cover the period 1953–73 for the aggregated level and 1953 to 1972 for the individual industries. The preliminary specification of the model has been completed and the results for the private nonfarm sector and total manufacturing have been written up in a draft manuscript. The model was estimated for the period 1953 to 1971 and conditional forecasts of output prices, wage rates, materials prices, and costs of capital were generated for the period 1972–73. The results indicate that the model tracks the paths of the output and input prices very well both in the sample and in the forecast periods. The model is now being applied to the industry prices and the results should be ready this summer.

M. Ishaq Nadiri

Labor Market Models and the Rate of Inflation

The theme of this research project is an attempt both to improve the theoretical foundations of unemployment and inflation theory and to subject the major hypotheses of the models to em-

pirical testing. During the past year research has been conducted in three main areas: (1) econometric evaluation of wage and price controls, (2) the microeconomic theory of layoffs and wage rigidity, and (3) the welfare costs of changes in the unemployment rate.

(1) As a sequel to my earlier paper, "Wage-Price Controls and the Shifting Phillips Curve," summarized in last year's report, I published "The Response of Wages and Prices to the First Two Years of Controls," *Brookings Papers on Economic Activity*, No. 3 (1973). The paper contains a general discussion of the methodology of evaluating controls and the likely direction of biases. One of the biases appears to point to an underestimate of the effect of controls in the paper: an alternative version of the wage equation with variable rather than fixed coefficients on past inflation yields a considerably larger estimated impact of the controls. A source of bias working in the opposite direction is the assumption that real output and unemployment would have been the same without the controls. To the extent that nominal income is exogenous, unemployment would have been higher without the controls, and inflation would have been lower in the basic simulation. An alternative simulation indicates, however, that this source of bias is not large enough to reverse the major conclusions of the paper, that the controls program reduced the price level by more than 3 per cent between mid-1971 and mid-1973.

(2) Most recent microeconomic theorizing on labor markets (Phelps, Mortensen, Friedman) explicitly assumes that the only method by which firms can adjust employment in a recession is by reducing wages sufficiently to induce the desired number of employees to quit voluntarily. No explanation is offered for layoffs or quantity rationing, and the models all generate a vertical long-run Phillips curve, which counterfactually implies that the long period of high unemployment during the U.S. Great Depression should have been accompanied by an accelerating *deflation*. In a working paper titled "The Microeconomic Foundations of Wage Rigidity," I explore the workings of a model in which an individual firm considers several alternative "contracts" among which employees can choose, including flexible wages with continu-

ous market clearing, or fixed wages with a higher variance in employment. The optimal choice of contract for a firm depends on several parameters. First, if employees are more averse to income fluctuations than are firms, they will be willing to accept a lower mean wage to be insured against income variation, and they will prefer a contract in which neither the wage rate nor employment varies at all. Second, with downward sloping demand curves for labor, firms will make greater profits with a fixed wage and variable employment than with a fixed wage and fixed employment. Third, a regressive tax schedule (e.g., welfare and unemployment compensation) favors variable employment, since the government pays part of the wage during unemployment and allows firms to pay a lower mean wage. A progressive tax schedule, on the other hand, favors fixed employment. Fourth, firms with uncertain labor-supply schedules will prefer to adjust employment directly by layoffs rather than gamble on wage reductions, because they simply do not know how workers will respond to a reduction in wage rates.

In a final section of the paper I attempt to explain the tendency of wage rates to be more flexible upward than downward, in contrast to the complete symmetry of the model considered in the preceding paragraph. Although a firm can reduce its employment by layoffs, it can increase its employment by rehiring ex-layoffs only up to a point. After that it must pay a higher wage to induce extra labor input, either by paying overtime to its existing workers or by raising its wage rate sufficiently to attract new applicants. It will always be optimal to combine these two methods, with an increasing reliance on new hiring relative to overtime for relatively large increases in labor demand because of the convexity of the overtime offer curve of workers.

(3) Although there is a relatively large literature on the welfare cost of inflation, little has been written on the welfare cost of unemployment. My paper, "The Welfare Cost of Unemployment," *Brookings Papers on Economic Activity*, No. 1 (1973), suggests a conceptual framework and presents detailed empirical estimates. The output lost when unemployment increases is counterbalanced in principle by the value of extra home activity and by the value of extra

unemployment in terms of the higher wage rate that an individual will secure by extending the time spent looking for work. The value of extra unemployment and home activity are relatively small compared to the value of lost output, mainly because profits, taxes, and unemployment compensation drive a "wedge" between the value of extra output in market prices and the extra after-tax income that an individual actually gains when he leaves home activity or the unemployment rolls to begin market work. With no allowance for the value of home activity or unemployment, a temporary one percentage point increase in the unemployment rate is estimated to cost society 2.8 per cent of GNP, whereas with the allowance the gain is reduced to 2.3 per cent.

A permanent increase in unemployment, however, involves a much smaller loss of output, because the short-run productivity shortfall caused by labor hoarding will disappear, and the lower level of labor input will require a smaller capital stock, freeing the resources previously devoted to paying the interest and depreciation charges on the extra capital. A final, more conjectural, gain is the greater efficiency of an economy with relatively few job vacancies and high unemployment, because vacancies can be filled faster and firms do not have to fill vacancies in advance by hiring superfluous employees. The paper estimates that permanent increase in the unemployment rate from 4 to 5 per cent would cost society only 0.7 per cent of GNP, as compared to the 2.3 per cent cost of a temporary increase in the unemployment rate by the same amount.

Robert J. Gordon

The Measurement of Durable Goods Prices

During the past year I have completed the first draft of a full-length monograph, "The Measurement of Durable Goods Prices." On the basis of fragmentary evidence that I had collected in earlier research, I became convinced that the official U.S. deflators for investment goods, primarily based on individual prices collected by the Bureau of Labor Statistics for the wholesale price index, contain a serious secular bias. In order to test the hypothesis that the secular increase in investment-goods prices has been slower than that of the official price index, I set about collecting new data from alternative sources, primarly (1) mail-order catalog prices, (2) unit-value indexes for narrowly defined commodities as collected in the U.S. Census of Manufactures, (3) prices of used cars and tractors from appraisal manuals, (4) records of equipment purchases from individual steam-electric generating stations, and (5) rental data for electronic computers.

The overall results are quite striking. The new index actually *declines* by 10 per cent between 1947 and 1970, whereas the official index for exactly the same commodities with the same weights rises by 85 per cent. As a consequence, the annual rate of growth of real equipment investment during the period 1947 and 1970, estimated to be 3.6 per cent in the official data, is a much higher 7.2 per cent when the official investment statistics in current dollars are deflated by the new price indexes. The results indicate a continuous rise in the investment-income ratio, in comparison to the relative stability exhibited in conventional data. Perhaps the most interesting implication is the substantial divergence between the prices of durable goods, measured in this study, and the prices of nondurable goods and services. Although the study does not contain any direct information on the prices of nondurable goods and services, the large number of items that have remained roughly constant in quality (meat, dairy products, haircuts) suggest that biases, if any, in the official statistics are much smaller than in the area of durable goods.

The study is designed to measure not only the extent of secular improvements in quality, but also the extent to which transaction prices are more sensitive than list prices to changes in economic conditions. For this reason all the data collected refer to transaction prices—unit-value indexes, mail-order catalog prices, and prices of used vehicles can all be interpreted as proxies or close substitutes for true transaction prices. 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 for 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, with much closer attention than in previous studies to the correction of all prices for changes in accessories. This proves to be particularly important for automobiles and tractors. For instance, approximately 34 per cent of the price of a 1970-model tractor is accounted for by accessories and attachments that were not available in 1947. Hedonic regression studies that simply regress list price, including attachments on horsepower, seriously overstate the secular increase in prices. The tractor regressions also reveal, as do those for automobiles, a very substantial reduction of the prices of used models relative to the prices of new models. Since there were no marked changes in depreciation rates during the interval of study, these reductions in used prices are interpreted as reflecting a reduction in the true transaction prices of new models relative to list prices, owing to the growing importance of discounting.

An unusual feature of the study is its attention to cross-checking results by developing comparisons of "closely similar" models at the beginning and end of the sample. For instance, the hedonic regression results for refrigerators, washing machines, and air conditioners are compared with price indexes constructed for similar models from data presented in *Consumer Reports* in the late 1940s and mid-1960s. In each of the three cases, the *Consumer Reports* index exhibits a substantially more rapid secular rate of *decline* than the hedonic index. One important reason for this decline is the steady improvement in electricity consumption for refrigerators and air conditioners, an improvement in quality for which the hedonic technique does not correct. The "comparisons of closely similar models" suggest that, if anything, the rather dramatic results of the study based on the hedonic indexes may actually understate the secular bias in the official deflators.

Robert J. Gordon

Aggregation of Production Function and Explanation of Wages

The purpose of this study is to examine the reasons why aggregate production functions appear to fit empirical data well even when the technological conditions for aggregation of individual firms' production functions are not met. Our strategy is the construction, inside a computer, of an artificial industry composed of firms whose individual technologies do not permit aggregation of their stocks of capital goods. We simulate a sequence of labor-market equilibria for this industry, driven by exogenous changes in the supply of labor and in the investment of each firm. We then aggregate the homogeneous output and homogeneous employment of the whole industry and construct a capital aggregate—which has no technological significance. Nevertheless, we estimate an aggregate production function from the time series of aggregates; and we also estimate "the" elasticity of substitution between labor and "capital" from the time-series regression of output-per-worker on the real wage. We are particularly interested in the closeness with which the marginal product of labor, estimated from the fitted production function, tracks the equilibrium real wage as generated in the simulated labor market.

We have a functioning computer program and have now completed most of our production runs with the model. We are studying the results for whatever "inductive" inferences they contain. For example, when the firms with the highest elasticities of substitution are growing faster than the others, the aggregate production function tends to estimate an industry elasticity of substitution that is so high as to be outside the range of firms' elasticities of substitution.

We expect to complete a paper summarizing our methods and results in the summer of 1974.

Franklin M. Fisher
Robert M. Solow

Measurement of Economic and Social Performance

Introduction

This project, which began in May 1972 with funding from the National Science Foundation, originates from the same questions that have given rise to interest in social indicators. Whatever vagueness attaches to the term "social indicators," efforts to construct them were largely

fired by a widespread dissatisfaction with the existing economic indicators. Since the most widely used economic measure of the nation's performance is the set of national income accounts, or simply GNP, this dissatisfaction has naturally been directed at the official GNP statistics.

The response, sometimes called "the social indicator movement," proceeded, very broadly speaking, in two directions: (1) going beyond the economic phenomena traditionally measured in the form of income, employment, prices, spending, investing, etc., to construct indicators of the health, education, environmental quality, civil rights, public safety, cultural participation, etc., aspects of the nation; and (2) extending both the traditional economic and the newer social measurements by examining their diffusion or distribution among income groups, social classes, and areas of the country.

The study involves both aspects of the social indicator effort. The work of Kendrick, Eisner, and Peskin has been concerned with extending the existing economic aggregates through measures of hitherto neglected aspects of nonmarket income and social costs or benefits. The work of the Ruggleses and Moss, on the other hand, has focused mainly on developing microdata sets that would permit better analyses of the distribution of various measures of social costs and benefits by income groups, regions, cities, social classes, etc. The work of Juster and Gronau on the measurement and analysis of time use, including a field experiment on the methodology of measuring time use and several studies in the analysis of nonmarket time, is relevant to both areas since it develops new measures on the individual household level that should eventually be reflected in aggregate accounts. The various parts of the project thus are all concerned with fitting new types of economic and social measurements into a general comprehensive framework that can both serve as an integrating device and provide the context for analysis. The specific subprojects are as follows.

1. Extension of the aggregate national economic accounts
   a. The Formation and Stocks of Total Capital—John Kendrick

b. Measurement and Analysis of National Income—Robert Eisner
   c. National Accounting and the Environment—Henry Peskin
2. The development and utilization of microdata sets
   a. The Integration and Analysis of Microdata Sets for the Household Sector—Richard and Nancy Ruggles
   b. Lifetime Income Study—Milton Moss
3. Measurement and analysis of time use
   a. Study of Time Use—Thomas Juster
   b. Valuation of Nonmarket Time—Reuben Gronau

Richard and Nancy Ruggles

The Integration and Analysis of Microdata Sets for the Household Sector

This project was undertaken to develop techniques for synthetically matching microdata sets. The data sets being used are the 1960 Public Use Sample, the 1970 Public Use Sample, the Longitudinal Employer-Employee Data file of the Social Security Administration, and the Individual Income Tax Model of the Internal Revenue Service. An article titled "A Strategy for Merging and Matching Microdata Sets," which appeared in the April 1974 issue of the *Annals of Economic and Social Measurement,* outlined the basic methodology that is being used. A paper on "The Role of Microdata in the National Economic and Social Accounts" was presented in Rio de Janeiro in January 1974 at the Second Latin American Conference of the International Association for Research in Income and Wealth. This paper described how microdata sets can operationally be integrated with the national economic accounts to provide distributions of economic and social measurements and to create a basis for microanalytic simulations. It will be published in a forthcoming issue of the *Review of Income and Wealth.* A second paper involving the use of microdata sets relating to households and individuals was also presented at the Rio conference by Edward Wolff of the project staff. Wolff's paper was entitled "Social and Demographic Factors in the Distribution of Occupational Earnings." Finally, Richard and Nancy Ruggles carried out an anal-

ysis of age-earning profiles, birth cohort patterns, and work history and earnings size distributions by sex and race over the period 1957–69, based on the Longitudinal Employer-Employee Data (LEED) files of the Social Security Administration. This paper, entitled "The Anatomy of Earnings Behavior," was presented to the Conference on Research in Income and Wealth in May 1974.

Nancy and Richard Ruggles

Measurement and Analysis
of National Income

Research in this area has involved setting up a Total Incomes System of Accounts as a possible framework for revised and expanded measures of income, product, and investment.

The economy is divided into three sectors: enterprises, government, and households. The enterprise sector in turn is subdivided into four subsectors: corporate enterprises, noncorporate enterprises, nonprofit institutions, and government enterprises. For each sector and subsector there are income and product accounts. Similarly, there are saving and investment accounts for each sector and a national saving and investment account.

Although market measures are used wherever possible in establishing valuation, the income and product accounts are not designed to show payments and expenditures and they are in no way restricted to market transactions. The output of each sector (or subsector) must pass to the household sector in the form of consumption or to any sector as intermediate product or capital accumulation, must be retained as capital accumulation in the sector of production, or be sent abroad. Goods and services may be transferred, however, as well as sold, with the output credited to the sector of production, and consumption, capital accumulation, or receipt of intermediate product recorded for the transferee.

Gross output can be expected to be considerably higher than in conventional accounts because investment in all forms of capital in all sectors is included as well as products of unpaid household work and uncompensated factor services such as are performed by volunteers and military draftees. Gross national product also includes the amount of government subsidies to production as well as the final product of media financed by advertising, such as television programs. The latter are considered enterprise transfers, generally of consumption services to households.

Gross national product is reduced, however, by subtracting expenses related to work and other "intermediate" output, whether or not sold by one enterprise to another. Hence, commuting expenses are subtracted from gross labor income, and much of government output, particularly defense services, is viewed as a transfer of intermediate products to enterprises, "purchased" in whole or in part with indirect business taxes. Net national product and net national income are, of course, substantially further reduced by capital consumption charges relating to the expanded category of capital, tangible and intangible, including revaluations or capital gains. Although capital consumption allowances thus relate to current valuation of capital rather than original cost, capital gains net of the general price level effect are included in gross national product.

Among major departures from conventional accounts, but generally consistent with current work by John Kendrick, is the imputation of interest and depreciation charges on household and government capital. Interest is imputed only on tangible capital, however; intangible capital is assumed to be held by households or enterprises and their income is included in factor payments or surpluses. Household product includes capital accumulation in the form of child-rearing and education and comprises unpaid household work as well as the opportunity costs of students.

A fair number of fresh estimates and calculations have been completed but in the main we are attempting to flesh out the framework by rearranging and reclassifying items already included in the BEA accounts and by cannibalizing as far as possible from estimates of other investigators in this area. Major input is anticipated from the microdata sets and from the work of other investigators at the National Bureau concerned with the measurement of economic and social performance.

A recently completed doctoral dissertation by John J. Soladay, "Measurement of Income and

Product in the Oil and Gas Mining Industries," contains revised estimates of output and capital accumulation in these industries. Soladay has related discovery and extensions and revisions of estimates of new pools of oil and natural gas to subsequent output of these resources. Employing least square regressions and a rational lag estimator, he estimated a time path of output from accumulated reserves. Utilizing (and where necessary extrapolating) ratios of revenue to output, depreciation of existing reserves and present values of accumulation of reserves then follow from selection of discount rates. The present values of additions to reserves are included in gross capital accumulation and the depreciation of these reserves is included in capital consumption. We hope to use this approach to sharpen and expand the preliminary estimates of capital accumulation, income, and output that have been prepared thus far for the oil and natural gas industries.

A comment relating to capital gains and the appropriate definition and measurement of income from endowment of nonprofit institutions was published in the May 1974 (Papers and Proceedings) issue of the *American Economic Review.*

Robert Eisner

National Accounting and the Environment

We have completed a first draft of the methodological portions of a monograph describing how the income and product accounts can be modified to measure the flows of environmental asset services. Basically, each two-digit SIC production sector account is modified by adding to the input side an entry approximating the value of environmental asset services used by the sector. For the most part, these services are those provided by air, water, and land to accommodate the sector's waste disposal needs. In principle, the value imputation is determined by estimating the dollar costs to the sector as its access to the asset is increasingly limited.

We modify the output side of each sector account by deducting an estimate of the value of damage to affected persons resulting from the sector's use of environmental assets. Generally, these damages arise because the disposed wastes adversely affect property and biological processes (e.g., human health). In principle, the damage value imputation is determined by the amount people would be willing to pay in order to avoid increasing levels of damage.

In the monograph we show how these sector accounts consolidate to a national modified gross product account, the entries of which form the basis of several alternative measures of gross economic activity. However, most of the discussion concerns the problem of putting into practice the valuation principles. As a matter of convention and to conform with the accounting practice pertaining to ordinary marketed goods, we define the accounting value of environmental asset use (or resulting damage) as the product of physical units of asset use (or physical units of damage) times the value of the marginal unit. Methods are suggested for approximating this valuation from various existing estimates of the cost of pollution control and the benefits of pollution reduction.

A vast amount of data on pollution generation, control costs, and environmental damage broken down by two-digit SIC is necessary to implement the accounting principles. Since such breakdowns are not readily available, it was necessary for us to generate the data by analyzing over 200 specialized studies on control costs and pollution generation. The data on generation and costs are essentially complete for air and water pollution. Information on environmental damage is currently being collected, although the data problems here are much more difficult.

Rough, but comprehensive, estimates of the value of environmental asset services and associated environmental damages should be available shortly. These will enable us to complete a crude set of modified accounts before the end of the year.

In the interim, the unique bank of data already assembled has proven useful in several related research efforts. For example, these data were a principal input for a paper on "The Distributional Implications of National Air Pollution Damage Estimates," by Henry Peskin, Leonard Gianessi, and Edward Wolff, prepared for the Conference on Research in Income and Wealth at the University of Michigan, May 15–17, 1974.

Henry M. Peskin
Leonard P. Gianessi

Lifetime Income

This project is directed toward an improved understanding of the lifetime distribution of income among persons and households. We are constructing profiles of income growth for different groups of persons and households over the span of their adult life and examining the way in which these patterns have been changing for successive birth cohorts.

We have compiled data for as many cohorts as could be gleaned from published reports of successive censuses, current population surveys, and a special tabulation from the Social Security Administration's continuous work history file. The data cover a period of over thirty years, based on decadal changes (census and CPS data) and quinquennial changes (social security data), and provide time paths of growth in total money income and/or earnings for individual cohorts as they age. Average earnings of a cohort rise perceptibly during the work life, reflecting such factors as age and experience, job shifts, changing duration of employment, and economy-wide changes in productivity and wage rates. An attempt to account for these various factors (in combination at this stage) is discussed below in the section on analysis of earnings.

The cohort data over the decades studied provide an improved basis for estimating differences in total lifetime income and in the rate of change in the early stages of life compared with the later stages of life. In general, the cohort data point up the rather sizable understatement of a typical individual's income growth if it is estimated from an annual cross-section, as has been done to date by the Census Bureau. The cohort data also show relatively larger percentage increases in later stages of life than do the cross-sectional differences by age at a given point in time. Such limitations in cross-sectional data have been recognized by the Census Bureau but have been explored in only a limited fashion.

An additional contribution of this study issues from an inquiry into the different lifetime paths of income by source—namely, earnings, property income, public transfer payments, and other income, mainly private pensions.

In contrast to the usual lifetime studies, which have been confined for the most part to the age sequence from 18 to 64, ours explores the time path of income for ages beyond the work life. Given the limitations of data of income by source, most of this work presently is limited to the time path of earnings.

With regard to *earnings*, we have attempted to determine the relative importance of various components of change in earnings—namely, changes due to:

1. Wage-rate changes in specific occupations, and a complex of changes, reflecting:
   a. differences in the duration of employment for different groups;
   b. shifts within and among occupations and industries;
   c. various other sources of earnings, such as fringe benefits, including private pensions and stock option arrangements.

At any given time differences in pay among earners reflect differences in wage rates in the different occupations in which the earners are employed. *Over time*, the rise or fall in pay differs from one earner to another depending on differential changes in the wage rates of different occupations and in the different shifts of earners (including the self-employed) from one role to another in a given occupation or from one occupation to another.

In the pilot inquiry we have been able to determine very broadly, for the decade of the 1960s, the relative importance of wage-rate changes as against all other factors mentioned above. It would appear that aggregate earnings increased by approximately 6 per cent per year. Of that change something in the neighborhood of 5 per cent appears to be due to changes in wage rates in individual occupations, with rather little variance from one occupation to another in the annual rate of change over that period. Thus, increases due to occupational shifts—i.e., relative increases in the number of earners in higher-paying positions—and other factors appear to be of the order of 1 per cent per year.

Our studies of cohort earnings over time indicate that inequality or the dispersion in earnings increases as a cohort ages, when dispersion is measured by Gini ratios, coefficients of variation,

or Lorenz distributions. Over broadly similar periods, however, we have found that percentage increases in wage rates among occupations in the private and public sectors, over spans of about a decade, seem to be uniform from one occupation to another. This suggests that shifts within and among occupations by members of the same cohort proceed through the working life of the cohort in such a way as to continue to widen the dispersion in their earnings.

Our calculations, based on data from a special tabulation of the March 1971 Current Population Survey, suggest that inequality in property and other types of income increases by age even more markedly than inequality in earnings. These sources of income need to be explored much more fully in the next phase of the project. Inequality of property income appears to widen for a given cohort over its work life, and the widening continues to a degree even after retirement. It is not clear, however, whether the rise in inequality has been greater for recent cohorts than for earlier ones. Such a comparison among cohorts would have to be investigated in the next phase of the study.

Milton Moss
Jane Duberg

Time Use

The pilot study of time use among American families had as its principal objective the investigation of alternative ways in which time use measurements could be obtained from samples of American families. Subsidiary objectives of this pilot study were to examine the role of time allocation in household decision making, with particular focus on the effect of parental time allocations to preschool and school-age children in producing educational achievement.

Methodological Studies

A number of small-scale methodological studies have been completed, with replications to ensure the stability of findings, in the course of the pilot study. One such study is now in process, and results are now coming in from the field.

As background for the methodological work, it should be pointed out that there are major inconsistencies among estimates of time alloca-

tion obtained in various ways, and these inconsistencies cast doubt on the results of many studies that use relatively simple and straightforward methods of obtaining data on time use. Two cases in point can be cited. It has been argued that there are considerable differences in the amount of time devoted to preschool children by parents with different socioeconomic status, with higher-status families investing more time in children than lower-status ones. The detailed estimates of time use obtained by diaries in the 1965 multi-national study of time use do not support that view: amounts of time invested in children by various socioeconomic groups in the 1965 study are not very different. Thus any major difference in parental investment would have to take the form of differences in the quality of time spent with children rather than in the quantity. And a recent national study conducted by the Survey Research Center of time spent in "volunteer" activities, using relatively straightforward techniques for obtaining the data, is also inconsistent with the more detailed data obtained from time budgets. In the national study, time reported spent on volunteer activities is much greater (amounting to eleven hours per month per family on the average), than in the detailed time budget estimate of roughly two–three hours per month per family.

Thus the issue of how to measure time use is important, since there are serious potential biases in many of the methods by which such data are obtained. Moreover, many judgments about policy in areas like transportation and recreation use these data as inputs.

To test the accuracy of the diary technique, we developed a small mechanical device about the size of a package of cigarettes, which could be carried around by a respondent to monitor daily activities. The device was programmed to emit a "beep" signal at random intervals, and respondents were asked to record their activities at that instant. Since the devices were programmed to signal at unknown intervals, respondents' normal pattern of activity should not have been affected by trying to outguess the signal and to arrange their activities so that the signals sounded at more convenient intervals. And since each device yielded some thirty-two observations per respondent per day (sixteen

hours of random signals averaging out to two observations per hour), we were able to obtain a large sample of activities from a relatively small sample of respondents.

The results of this comparison show that, on the whole, the proportions of time spent in various activities revealed by the mechanical monitor are very close to the diary proportions. There are activities that apparently are systematically over-reported in diaries, and others systematically under-reported, but on the whole we conclude that the diary method of obtaining time budget estimates seems quite valid for the particular time period employed—the twenty-four-hour time span over which measurements are made.

Establishing the accuracy of the twenty-four-hour diary carries us part of the way toward resolving the measurement problem, but it does not resolve certain issues. There are first of all substantial individual differences in how families and people spend time, depending on variables like time of the year. In order to get a reliable measure of individual or family time allocation over a span of time that is meaningful for economic analysis, it would be necessary to collect a substantial number of twenty-four-hour diaries randomly distributed over all possible times when activities might be expected to vary. Although such a procedure is feasible, it is extremely costly. Thus, it would be useful if we could obtain estimates of time use that cover longer spans of time than a day. For example, we need data for spans like a week or a month, as well as estimates for "typical" amounts of time allocated to various activities. Here, what evidence we have is not encouraging: estimates of time use over longer spans of time are precisely those that calibrate very poorly with the diary estimates, and we know from the monitoring experiment that the diary estimates accurately represent how time is allocated.

Hence, we have become interested in developing a methodology for measuring time use over extended spans of time. An interesting possibility, which we have pretested on a very small sample and are now replicating on a somewhat larger one, is to obtain time use estimates in terms of duration and frequency for a sample of "stylized" activities that people engage in. To illustrate, we can get estimates of time spent in "volunteer" activities by asking how much time was spent in such activities yesterday, or last week, or last month, or "typically" per month, simply by asking a direct question. An alternative is to determine when an individual last engaged in an activity that falls in the category of volunteer effort, how much time he spent the last time he undertook that activity, and how often he undertakes such activities. Multiplying duration (of last episode) by frequency gives us an alternative estimate of total time spent on that activity by the individual or family. More generally, if we could devise a set of categories that represented all or nearly all types of activities, or if we could devise a set of activities that represented a random selection from among all possible activities, then by obtaining duration of last episode and frequency (both of which may be more easily and accurately measured by survey) we would have a viable methodology for estimating time allocation over spans like weeks or months.

Substantive Research on Time Allocation

Although the primary focus of the time use pilot study was on the methodology of measuring time use, we expected and were able to make some headway on substantive issues. The principal area under investigation here is the impact of both quantity and quality of parental time on the school achievement of children.

To examine the question, one would ideally like to have records of achievement obtained prior to the time that youngsters start school, since that is the time span over which parental influence must be the strongest—or at least is not contaminated by any possible schooling influences. We have been able to obtain a collection of data, originally destined for quite different purposes, which is almost ideally suited for our purpose. Some years back, psychologists at the Child Development Center at the University of Michigan developed and applied a series of preschool tests of various sorts to identify children who are likely to present problems when they start school. A battery of some twenty-seven test measures were applied, many of them specifically developed to measure various aspects of achievement on the part of preschool children.

In addition, several background variables on the parents are available for the analysis.

After a considerable delay, we have finally obtained permission from the school system that sponsored the original study to go back to the parents of the children who were tested and conduct a follow-up interview. This follow-up interview focuses on parental time allocation, especially allocation of time involving the children who were the subjects of the original study. Although these children are now in the second grade, hence are about seven years old instead of the four years of age they were when the achievement tests were given, we assume that relative differentials in the distribution of time allocation among children are not likely to be different now from what they were earlier. Thus we plan to use measures of parental time inputs that relate to some years after the output data (achievement scores) were obtained, assuming that present time inputs are highly correlated with past ones.

While we are testing the influence of parental time inputs in the achievement function, we are simultaneously conducting a methodological test on ways of measuring time. The families for whom we are obtaining time input data are being asked two kinds of questions. The first is a relatively straightforward set of questions concerning typical amounts of time spent on various kinds of activities with children, along with a time use diary for one day. The second is the "stylized" situation measure, in which we ask about the last time each of a set of episodes occurred, how long it lasted, and how often such episodes occur.

We are also attempting to get a number of independent measures of time quality, as opposed to quantity. That is, we will not necessarily have to rely on parental background (education, occupation, etc.) in order to measure time quality. Instead, we will be using measures developed in conjunction with the Child Development staff at the University of Michigan in order to get specific measures of interaction between parents and children, measures that should serve as a good proxy for the quality of parental time.

Other substantive areas of work are concerned with the measurement of time spent in voluntary activities and the measurement of the effect on time allocation of shifts from a five- to a four-day work week. The first of these is a by-product of a Survey Research Center project concerned with the philanthropic behavior of U.S. families. Data have been obtained measuring philanthropic contributions of both time and money. The second is in conjunction with the dissertation work of a Michigan Ph.D. student, and we are providing some field support for a study concerned with before and after measures of time use for families who had been on a five-day week and recently shifted to a four-day week.

Prospective Research

Assuming that the major methodological problems will be resolved, follow-on studies should attempt to collect time use data for national samples, focused around two kinds of uses:

1. Combining data on time use with other microdata files, using the match and merge techniques being developed by Nancy and Richard Ruggles in another part of the present NSF project, with the object of building a socioeconomic data base containing a rich set of behavioral characteristics for families. The resulting data file would be a prime source for generating economic and social accounts that would permit representation of nonmarket as well as market activities.

2. The time use data would permit investigation of a number of economic problems wherein time inputs are likely to be of major significance.

F. Thomas Juster
John Robinson

Valuation of Nonmarket Time

The purpose of this study is to analyze the allocation of a household's time among various activities. Evaluating women's economic performance in the nonmarket sector, incorporating household economic activity, and, in particular, estimating housewives' output in the national accounts raise some severe conceptual difficulties. Since there is no open market for inputs and outputs in this sector, one has to rely on imputations. My paper on this topic, entitled "The Measurement of Output of the Nonmarket Sector: The Evaluation of Housewives' Time," was

published in *The Measurement of Economic and Social Performance,* Studies in Income and Wealth, Volume 38; and I have also circulated for comment a working paper titled "The Wage Rates of Women—A Selectivity Bias." Currently, I am trying to analyze the household production process, focusing primarily on the behavior of married women: the amount of time they spend on work in the market, work at home and leisure, and the interaction between their time and money expenditures. Special emphasis is accorded the effect children have on their mothers' time patterns. I expect to finish the statistical analysis in the coming year.

Reuben Gronau

Business Cycles

Introduction

In view of the recent concern with the problem of identifying a "recession" and the critical role the National Bureau has hitherto played in establishing a chronology of recessions, John Meyer has appointed a committee of the National Bureau staff to advise him on this matter. The committee includes Charlotte Boschan, Solomon Fabricant, Edwin Kuh, Edward K. Smith, Victor Zarnowitz, and Geoffrey H. Moore (chairman). The group will consider the nature and timing of any National Bureau studies that bear on the problem of defining or identifying such phenomena as "recessions" or "growth recessions."

The staff committee's view is that the Bureau should, as in the past, publish findings concerning the existence of a recession only in connection with and as an incident to the publication of the results of research. That is, it should not undertake to issue current statements on whether or not a recession had begun or ended, independent of any research that utilized or required an answer to this question. In short, the National Bureau should not become involved in reporting current developments.

This does not, of course, rule out experimental studies concerning the definition or identification of recessions, or studies that compare recent developments with earlier experience, or studies of forecasting methods and performance. But our concern should be with research

and generalizations derived therefrom, not with current reporting.

This means that the Bureau will not likely become an authority for making promptly available findings on whether or not we are in a recession. This is partly because our research program is not focused in that way; partly because a prompt answer virtually requires a forecast, which raises the probability that any finding will be wrong; and partly because our review procedures (which should be carefully followed in this case as in others) take a long time to complete.

The committee has also considered how the Bureau's officers or staff should deal with questions of this sort from the press, public bodies such as the Joint Economic Committee, and the like. It is important, in the view of the staff committee, that those who choose to respond to such inquiries make it clear, where such is the case, that they are speaking for themselves and not for the Bureau.

Some of my own reflections on the problem of defining a recession; how soon it can be recognized; the distinction between recessions and "growth recessions"; and the evaluation of current data on leading indicators, employment, prices, and profits are contained in the March issue of the *National Bureau Report,* under the title "Measuring the State of the Economy." Some further observations are in *Economic Outlook U.S.A.,* Summer 1974, Survey Research Center, University of Michigan, under the title "Recession?".

In "Prices during Growth Cycles," presented at a Roundtable on Inflation held by the Conference Board in Canada, January 22, 1974, I set forth some evidence on the proposition that slowdowns in economic growth in the United States and apparently also in Canada have been accompanied by reductions in the rate of inflation. Declines in the rate of inflation were associated with virtually every growth recession in the United States since 1948 and did not occur at other times. Both parts of this proposition are important.

Contrary to a rather common belief, the United States has not experienced continuously accelerating inflation since World War II—it has had its downs as well as ups. But the declines in the rate of inflation have occurred only at times of

slower growth, never at times of rapid growth. This pattern is clearest in the prices of basic industrial materials, but the comprehensive index of industrial wholesale prices also shows a fairly regular response. So, too, with a lag, does the consumer price index.

A paper entitled "Some Secular Changes in Business Cycles," published in the *American Economic Review,* May 1974, points out that recessions have become less frequent, shorter, and milder in recent decades. One contributing factor has been the shift toward more employment in industries that are relatively recession-proof, notably the service industries. According to projections to 1985 by the Bureau of Labor Statistics, this shift can be expected to continue. If it does, it will have had the effect over a thirty-year span (1955–85) of cutting in half the percentage decline in total employment during an "average" recession.

It is generally thought that the shift toward more employment in government has been one of the stabilizing elements, because government jobs are relatively immune to recession. This is clearly true of aggregate employment by state and local governments. But recent work by Walter W. Ebanks shows that federal employment has declined in every one of the five recessions since 1948, and by percentages that rival those in the private sector. During the intervening expansions, federal employment has increased. Employment in the Defense Department has been primarily responsible for this pro-cyclical performance. Ebanks is preparing a brief report on his results.

Some aspects of the behavior of stock prices, bond yields, and the volume of stock and bond issues during business cycles are described in my paper, "Security Markets and Business Cycles," prepared for the *Financial Analysts Handbook.* A joint paper with Walter Ebanks, "Forecasting with Lagging Indicators," develops some of the properties of various types of indicators that lag at business cycle turns but nevertheless have interesting implications for forecasting. Other papers published during the past year include: "How Full is Full Employment?" American Enterprise Institute for Public Policy Research, July 1973; "Economic Indicator Analysis during 1969–72," in *Nations and Households*

in Economic Growth: Essays in Honor of Moses Abramovitz, Academic Press, 1973; "Productivity, Economic Growth and Inflation: Recent Experience in the Light of Mitchell's Hypothesis," in *Conference on an Agenda for Economic Research on Productivity,* April 1973, published by National Commission on Productivity, Washington, D.C.; and "Look at What Forecasters Do Right," New York Times, February 3, 1974.

Ilse Mintz's study, "Dating U.S. Growth Cycles," is scheduled for publication in the first issue of the new NBER journal, *Explorations in Economic Research,* to appear this summer. The report on *Forecasts with Quarterly Macroeconometrical Models,* by Yoel Haitovsky, George Treyz, and Vincent Su, is in press. Reports on other business cycle investigations follow.

Geoffrey H. Moore

Money

Work on our draft of a manuscript on "Monetary Trends in the United States and the United Kingdom, 1880–1970," has occupied us during the past year. We have completed Chapter 8 dealing with monetary influences on nominal income in the two countries and are well along in the following chapter dealing with the division of the change in income between prices and output.

One interesting finding is illustrated in Figure II-1, which plots our time series of secular rates of change in real income and implicit prices for each country. The figure, which is based on rates of change spanning three business cycle phases, suggests that there has been a distinct change in the relation between prices and output over time. For both the United States and the United Kingdom, there is a clear positive correlation between rates of change in prices and output up to World War I. For the United States, the relation continues through World War I and up to World War II. For the United Kingdom, there is no correlation during World War I but a positive correlation reemerges in the interwar decades. Then after World War II, the correlation becomes negative instead of positive for both the United States and the United Kingdom. For the war and early postwar years, the evidence is unreliable because the price measures were distorted by wartime price controls

Figure II-1

Rates of Change Computed from Moving Three-Phase
Averages: Real Income and Implicit Prices

Per cent per year
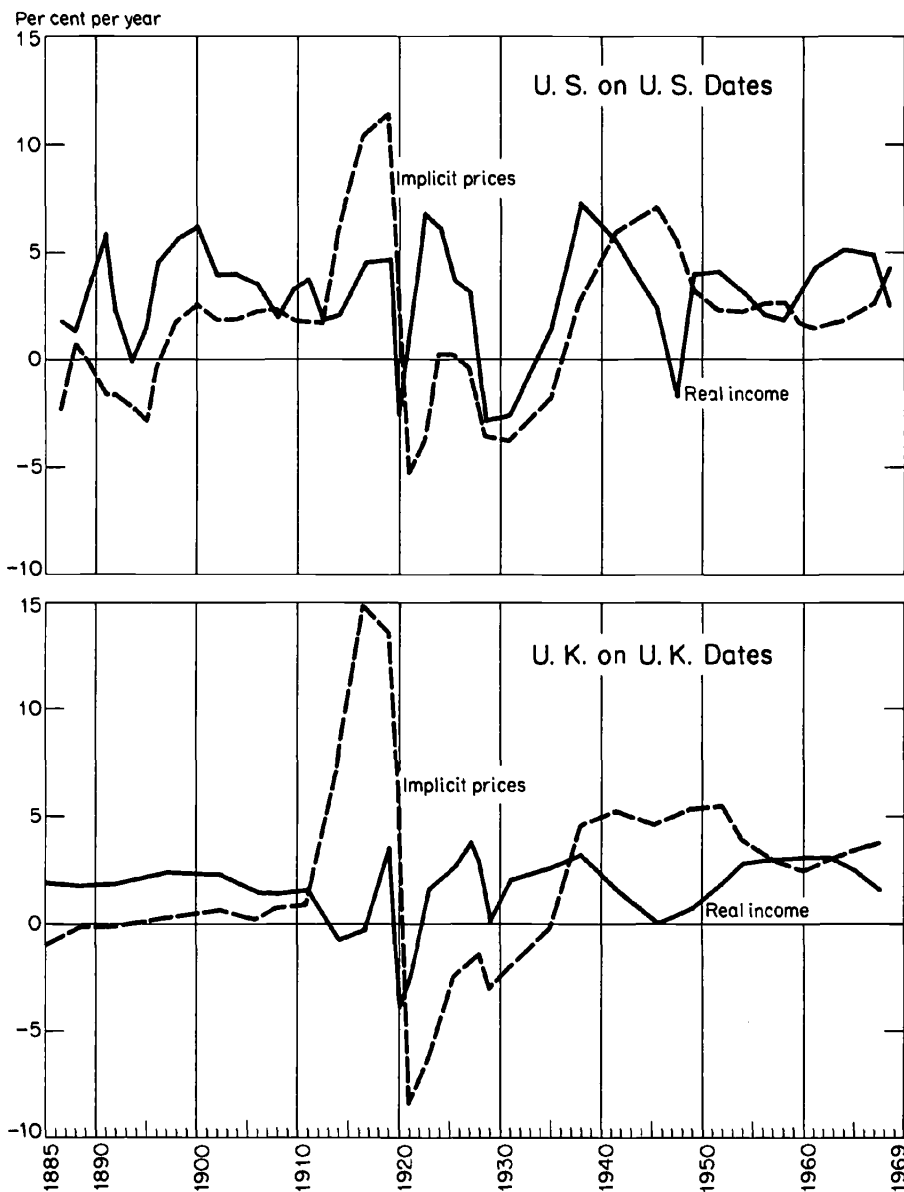
and their subsequent unwinding. However, the negative correlation is clearly etched for the whole of the postwar period. The post-World War II period is obviously not a simple replica of the pre-World War II period.

The difference shows up sharply in correlations between rates of change in prices and output computed separately for the period before World War I, between the two wars, and after World War II (Table II-1).

In our current work, we are focusing on possible explanations of the change in the correlation from before to after World War II. In addition, we plan to examine price and output data for each country at shorter intervals than the phase average data underlying our trend study. An inverse relation of the data between phases is consistent with a positive relation within phases. To check the relation within phases, we have assembled annual, quarterly, and monthly series of prices

TABLE II-1

| | Correlation between Phase Rates of Change in Prices and Output for | |
	U.S.	U.K.
Pre-World War I	.520	.201
Interwar Period	.712	.766
Post-World War II	−.322	−.822

and output, less comprehensive in some cases than the national accounts measures used in the trend study. For cyclical analysis of the monthly and quarterly series, we need a chronology of turning points for post-World War II rate of change reference cycles. Ilse Mintz's deviation from trend dates are available for the United States; for the United Kingdom, we anticipate that a chronology will be forthcoming as a by-product of the NBER international indicator study.

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

Determinants of Investment

Work is nearing completion on the monograph based largely on data from McGraw-Hill capital expenditure surveys.

Analysis of inventory investment points to a substantial role for expected sales. A prime determinant of annual inventory investment by a firm is the excess, over the stock of inventories at the end of the past year, of the product of an average past inventory-to-sales ratio and sales expected in the following year, these last as projected from expected sales changes. There is also some considerably smaller carryover from the previously expected increases in sales. The error in sales expectations, defined as the difference between actual and expected sales of the current year, plays only a small role, possibly reflecting a balancing of positive intended investment in inventories, relating to the expectational content of current sales, and unintended inventory disinvestment wherein unanticipated sales and shipments exceed output.

An attempt to discern a role for profits either in affecting inventory investment directly or in affecting its rate of response to expected sales

changes was not successful. There was some slight evidence that higher relative profits accelerated investment based on expected sales. However, coefficients of variables involving relative profits proved small, of varying sign, and of questionable statistical significance.

Several papers dealing with tax incentives for business investment have been published (*National Tax Journal,* September 1973), or are scheduled for publication (*George Washington Law Review,* Spring 1974; and, with Patrick J. Lawler, *American Economic Review,* March 1975). A brief comment on "Econometric Studies of Investment Behavior" appears in the March issue of the *Journal of Economic Literature* and a lengthier paper on this subject in the March issue of *Economic Inquiry—The Journal of the Western Economic Association.*

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

Rational Expectations and Investment Behavior

During my tenure as research fellow, I have investigated the investment behavior of manufacturing industries in the United States, using quarterly data aggregated to the two-digit SIC level. The goal of this research is to build and test a model of investment behavior that is explicitly dynamic and explicitly incorporates uncertainty about future prices. A simple model that has these characteristics is a "rational expectations" model. In this model, decision makers are assumed to harbor expectations about future prices that coincide with the distribution of future prices that their actions generate. This assumption is based on an "efficient market" argument: any other expectations will generate lower expected profits, forcing a firm to change its expectations or eventually go out of business.

In a variant of this model, expectations are assumed to be adjusting toward "rationality." Since rationality requires that all decision makers have identical expectations, it is reasonable to assume that the rational expectations constraints on behavior will be only approximately satisfied. In a model with adjusting expectations, the rational expectations hypothesis may be tested.

I have also completed a paper on the use of

an "economic," or "operational," time scale in estimations using seasonal variables. The operational time method is used in estimating the start-to-completion lag for single-family houses in the United States; it is shown to be superior to seasonal adjustment of both series, estimation of separate lag structures for each month, or the variable lag distribution proposed by Tinsley.

Peter K. Clark

Short-term Economic Forecasting

Forecasts from the ASA–NBER Quarterly Surveys of the Economic Outlook are being regularly collected, analyzed, and interpreted by Charlotte Boschan and myself, with the assistance of Josephine Su. They are to be published quarterly in the new NBER journal, *Exp·orations in Economic Research*. A special questionnaire designed to obtain reactions of respondents to the Survey and to learn more about the methods and assumptions of the forecasters has produced considerable information. These data, collected in August 1973, have been tabulated and evaluated at the National Bureau, and a summary of the results was distributed to all participants.

Vincent Su and Josephine Su presented a paper "An Evaluation of the ASA–NBER Business Outlook Survey Forecasts," at the annual meeting of the American Statistical Association in December 1973. The paper was published in the *Proceedings* of the Business and Economics Statistics Section. I prepared two papers in this general area: "Simulations and Forecasting with Macroeconometric Models—An Overview" (IEEE Conference on Decision and Control, San Diego, December 1973) and "Forecasting in Economics: State-of-the-Art, Problems, and Prospects" (Conference on Research Needs in Forecasting, The Futures Group–NSF, New York, January 1974).

Plans have been drawn up for a new research project, Evaluation of Forecasts from Quarterly Econometric Models. A two-year research program is proposed to collect and analyze forecasts of the principal econometric models now in existence, to trace the sources of forecast error, and to develop some of the methodologi-

cal tools needed to accomplish this research in a satisfactory manner. The compilation of an ex-ante forecast record together with the model equations and assumptions used to produce it will constitute a basic resource for the analytical work on decomposition of errors. At the same time, theoretical studies will be undertaken (1) to develop simple estimation procedures that can be used to place all the models on a comparable basis, (2) to allow the computation of standard errors of forecast, and (3) to produce optimal multiperiod forecasts for dynamic models with autoregressive error structures. The principal investigators for the project, if suitable funding is obtained, will be Phoebus J. Dhrymes of Columbia University and myself. Vincent Su has already begun some of the preliminary work on the project.

A meeting to discuss this project was held in November 1973 at the invitation of Lawrence R. Klein, Chairman of the seminar on Comparison of Econometric Models. This group, sponsored by the NBER–NSF Conference on Econometric and Mathematical Economics, includes eleven model builders. The procedure for collecting forecasts and the framework of the project were discussed at the meeting.

Victor Zarnowitz

Evaluation of Cyclical Indicators

This study is a project financed by a contract between the Bureau of Economic Analysis (BEA), U.S. Department of Commerce, and Victor Zarnowitz. Contributions to the work are made by the BEA staff in Washington as well as by members of the NBER. The first major purpose of this research is to review the monthly BEA report *Business Conditions Digest* (BCD) and determine what changes in its format, scope, and content may be desirable. The report is a large compendium of economic indicators used by many analysts, forecasters, and administrators in government, business, and academic institutions. It is based on past studies of business cycles, national income, anticipations surveys, and the like, a large part of which represents the work of the BEA and the National Bureau. Recommendations aiming at further improvements

in BCD will reflect the availability of new and better data and analytical techniques as well as lessons drawn from an appraisal of the most recent developments in the U.S. economy and a reappraisal of earlier ones.

Analytical work on the review of the present BCD indicators and other time series considered for inclusion in BCD is well advanced. Measures of cyclical timing, conformity, amplitudes, smoothness, and currency have been computed for this large collection of series, and they are being variously processed and summarized. The results shed light on several important distinctions, notably between the characteristic behavior of real and current-dollar indicators, between timing and diffusion of the series at peaks and at troughs, and among groups of series representing different economic processes. A comprehensive, updated scoring system is being used to evaluate each series according to several criteria, such as a series performance as a cyclical indicator, its economic significance, and its statistical adequacy. The end product of this sifting will be a new selection of the principal indicators ("short list") and of all accepted indicators ("long list"), cross-classified by characteristic timing at peaks and at troughs and by economic process. It should also be interesting to compare the underlying measurements for still other groupings of these series (e.g., data on economic flow variables vs. those on stock variables; real vs. current-dollar value and price indicators; endogenous vs. exogenous policy variables).

We cross-classified the data by timing at peaks and at troughs and by economic process and plan to combine the resulting groups into composite indexes, cumulated diffusion indexes, and perhaps still other types of summary measures. The usefulness of such indexes for purposes of current business analysis and forecasting varies directly with (1) the consistency of their cyclical performance over time, (2) the promptness with which they can be computed, and (3) the confidence with which their contemporary movements can be interpreted. For example, a leading index is better (1) the greater the frequency and the smaller the dispersion of its leads at the business-cycle turns covered, and the fewer the "extra" turns in the index;

(2) the more current (promptly available) the data for the component series; and (3) the smoother the data—i.e., the more dependable index's current signals.

The selected indexes will be subjected to ex-post and ex-ante predictive tests using various methods (historical comparisons of the new and old indexes, filters, regression analysis, etc.). These tests will be applied to the relations between (1) the leading, coincident, and lagging indexes; and (2) the leading indexes and comprehensive economic aggregates.

In the course of this study, the present reference cycle chronology of the National Bureau for the U.S. economy in the post-World War II period has been reviewed and will be subjected to a few small revisions. Our report will include the full documentation of the results of the review.

Between January 1973 and February 1974, Victor Zarnowitz gave four progress reports to the BCD Technical Committee of the federal government in Washington, D.C. He also presented a paper on the plans for this study and some related matters at the CIRET Conference in London in September 1973.

The second major purpose of the study is an attempt to clarify the concept and advance the measurement of "growth cycles." These cycles can be tentatively defined as the observed consensus of specific cycles in the deviations of the main indicators of aggregate economic activity from their long-term trends. Ilse Mintz' earlier work paves the way for further research in this new area. The main objectives of this phase of the project are (1) to prepare a documented chronology of U.S. growth cycles; (2) to provide measures of timing, conformity, smoothness and other relevant attributes for a list of selected indicators of fluctuations of this type; and (3) to compute and test summary indexes based on the principal growth-cycle indicators. This work has close links to the study of international economic indicators recently initiated by Geoffrey H. Moore and Philip A. Klein.

BEA has extended the project for nine additional months through 1974 to include an exploratory study of U.S. growth cycles in the years since 1948 and a comprehensive comparison with the results of previous indicator studies.

International Economic Indicators

The objective of this study, which began in August 1973, is to show how selected lists of monthly and quarterly economic indicators for the major developed countries can be effectively organized to throw light on the current state of the business cycle, or "growth cycle," in the several countries and around the world. Our immediate target is to produce a graphic and tabular arrangement of the principal leading, coincident, and lagging indicators for each country, similar to that used for the U.S. in *Business Conditions Digest,* demonstrating the potential value of a current publication of this type produced regularly by some governmental or international organization.

Initial financial support for the project has been obtained from the U.S. Department of Commerce and from the general funds of the National Bureau. In addition, substantial resource inputs by private research institutes, central banks, and governmental and international agencies have been obtained in all the countries where we have pursued our inquiries. Over the next few years, if the project is successful in generating further interest and support, a large amount of analytical work should be done for each country to set forth the properties of the data; their cyclical behavior; their significance, limitations, and comparability; and their international interrelations. The importance of research along these lines is underlined by the profound consequences for international monetary relations, exports and imports, capital flows, balance of payments, and the rate of inflation that appear to result from the presence or absence of divergencies among countries in the state of the business cycle in which they find themselves at any given time.

Initial efforts have been directed toward developing contacts with statistical and research agencies in the several countries, obtaining information necessary to establish business cycle or "growth cycle" reference dates, determining whether matching lists of leading and other indicators can be obtained from each country, securing access to the historical data, and working up a bibliography of relevant studies. Among countries, priority in the work has been accorded to Japan, Canada, Great Britain, and West Germany, but individuals and organizations have also been contacted in France, Italy, The Netherlands, and Belgium. Furthermore, our exploration has uncovered research and active interest in this field in other countries, including Austria, Denmark, Sweden, Ireland, and Australia, as well as the OECD in Paris and the EEC in Brussels.

Our principal conclusions from the work to date are as follows:

1. The interest in what we are trying to do has been universally encouraging and supportive. In particular, there is a great deal of interest in many countries in systematic anaylsis of cyclical fluctuations along the general lines developed at the National Bureau for the United States.

2. The development of comparable reference cycle chronologies is a realistic objective for the reasonably near future in many industrial economies. Active use is now being made of such chronologies in Japan, Canada, West Germany, Great Britain, Italy, Austria, and Australia.

3. Interest is almost everywhere concentrating on "growth cycles." The evidence is overwhelming that business cycles still persist in market-oriented economies but often as uneven rates of growth in aggregate economic activity rather than as changes in direction. However, there is a clear need to apply a standard methodology to the data for different countries to derive comparable growth cycle chronologies. A preliminary effort to derive an "international growth cycle" on an annual basis since 1954 was reported in a paper by Geoffrey Moore, "The State of the International Business Cycle," presented at the Sixteenth Annual Forecasting Conference, New York Chapter of the American Statistical Association, April 19, 1974. The paper is to appear in a forthcoming issue of *Business Economics.*

4. There is a growing body of evidence that despite the tendency since World War II for cycles to exhibit differential growth rates, the notion of reliable leading, coincident, and lag-

ging indicators can be shown to apply in many countries outside the U.S. where the concept was developed. So far we have uncovered evidence of this sort for Japan, Canada, Great Britain, and Australia. A recent study along these lines has been conducted by Desmond O'Dea for the National Institute of Economic and Social Research in London. A portion of this study, "The Cyclical Timing of Labor Market Indicators in Britain and the United States," will appear in a forthcoming issue of *Explorations in Economic Research.*

Our strategy has been first to determine for each country what series are available to match the twenty-six indicators on the "short list" developed in 1966 by the National Bureau for the U.S.—twelve leading, eight roughly coincident, and six lagging indicators. This will give us a basic matching list, covering a wide range of economic data, to which can be added other indicators that are particularly strategic in each country. It will also give us most of the data needed to develop a reference chronology on a comparable basis for each country, which is the next order of business, since such a chronology is needed to determine leads and lags and other cyclical measures. Finally, we have arranged to obtain the actual historical data, in original and seasonally adjusted form, for the selected indicators, and expect in due course to include them in the NBER Time Series Data Bank. Once the data are in machine readable form, we can readily obtain (1) computer-plotted charts, (2) trend-adjusted data and rates of change, (3) turning point selections by computer program, (4) conformity indexes and other cyclical measures, and (5) composite indexes and diffusion indexes of leading and other groups of indicators. The results will be incorporated in the prototype copy that we are preparing for a possible periodical resembling *Business Conditions Digest* but covering the international field.

TABLE II-2
Tentative Median Timing Patterns at British Growth Cycle Turns,
1953–72, 25 Indicators Matching U.S. Short List

| | Median Lead (−) or Lag (+), in Months, at Reference Dates of British Growth Cycles | | | | | | | |
	P 12/55	T 11/58	P 11/60	T 2/63	P 8/65	T 8/67	Pa 12/68	Ta 2/72
12 Leading Indicators	−3.5	−4.5	−7	−3	−9	−9	−3	−18.5
7 Roughly Coincident Indicators	0	−2.5	+3	0	0	+3	+14	0
6 Lagging Indicators	+2	0	+6	+4.5	+6	+3	+22	NA

a. These two reference dates are based on the trend-adjusted Index of Industrial Production alone. The others represent a consensus among the trend-adjusted coincident indicators.

Quarterly series are treated as if they pertained to the middle month of the quarter.

Series used, each in terms of deviations from trend (centered 60-month moving average):

Leading Indicators
1. Average workweek, mfg.
2. Total wholly unemployed under 2 weeks
3. Net business formation
4. Net new orders, vol. index, Eng. Indus. total
5. Net new orders, pvt. ind. work, plant & equipment, excl. housing sector
6. Housing starts, private sector
7. Increase in stocks & work in progress
8. WPI, basic materials, mfgr. non-food
9. Stock price index, Financial Times
10. Gross corp. trading profits
11. Price/wages & salaries cost per unit
12. Hire purchase—increment in debt outstanding

Roughly Coincident Indicators
1. Employees in employment, production indus.
2. Total employees in employment
3. Total wholly unemployed, excluding school leavers and adult students
4. GDP—constant prices
5. Total disposable income, 1963 prices
6. Retail sales volume
7. Index of industrial production

Lagging Indicators
1. Total wholly unemployed—8–26 weeks
2. Fixed capital expend., plant & equip. (mfg.)
3. Stocks and work in progress
4. London clearing banks—advances
5. Treasury bills—allotment rates
6. Wages & salaries/unit of output

An example of our experimental work with British data, carried out with major assistance from the National Institute of Economic and Social Research and the Central Statistical Office of the British government, is given in Table II-2. It contains a reference chronology of growth cycles in the U.K., 1955–72, and summary measures of the cyclical leads and lags of groups of indicators that match, as nearly as may be, the U.S. short list. Leads are recorded at every turn by the leading indicators and lags at every turn but one by the lagging indicators, with the coincident group falling between in virtually every instance (there is a partial exception in 1967). Thus the results are substantially similar to those obtained for the United States, despite the fact that the British indicators were not selected on the basis of their own performance. Moreover, all the work with British data was carried out in terms of growth cycles—i.e., trend-adjusted data—whereas the U.S. analysis has hitherto been done with the raw data. It appears, then, that the critical notion of leading, coincident, and lagging indicators can readily be transferred to growth cycles as well as to other countries.

Although our immediate concerns have been focused as described above, we have begun to give some thought to a book reporting the substantive findings that will emerge.

Such a report, which we have tentatively entitled "International Economic Indicators of Business Fluctuations: An Application of NBER Methods to Post-War Growth Cycles in Industrialized Economies," could serve as a background volume for the proposed new monthly publication. The book would cover the role that the current study plays in filling the original intention of Burns and Mitchell concerning the international appropriateness of their definition of cycles, discuss the implications of a shift to a growth cycle concept, develop growth cycle chronologies on a comparable basis for the countries studied, and document the pattern of indicator behavior for each country.

We trust that a basic volume of this kind will demonstrate the value as well as the limitations of leading, coinciding, and lagging indicators during growth cycles in industrialized market-oriented economies. In this way, the book should

serve to introduce and interpret as well as to arouse interest in and justify a private, governmental, or international effort to produce a monthly publication that makes the current data widely available.

Geoffrey H. Moore
Philip A. Klein

Current Developments in Productivity: A Proposal

A prototype issue of a proposed journal or newsletter dealing with current developments in the field of productivity was prepared in the autumn of 1973 with the support of the National Commission on Productivity. The intended function of such a periodical is to bring together basic data and analyses essential to the appraisal of recent changes in productivity and costs in the United States and other industrial countries. Although no decision to publish the periodical has been made, some account of the content proposed for it may be of interest.

The protoype issue, tentatively entitled the Quarterly Productivity Review, contained a special article by former Secretary of the Treasury George P. Shultz titled "Saving the Taxpayer's Dollars Through Timely Capital Investment in Government." In addition, current developments were covered in the following sections: (1) Productivity and Cost Developments in the United States, (2) International Comparisons, (3) Productivity News Items, and (4) Statistical Tables.

Highlights of the domestic and international trends analyzed in sections 1 and 2, and the charts used to depict them, were as follows:

1. Gains in productivity (output per manhour) during the economic expansion that began in 1971 were about as rapid as in the expansions that began in 1949, 1954, 1958, and 1961. Wage and salary compensation rates rose more rapidly than in the previous expansions, and far more rapidly than productivity. Hence, unit labor costs also rose more rapidly (Fig. II-2).

2. For the nonfinancial corporate sector, where the available data distinguish nonlabor costs (depreciation, interest, and indirect business taxes) from profits, a sharp contrast emerges (Figure II-3). Nonlabor costs per unit of output remained unusually stable, offsetting

Figure II-2

Expansion Comparisons: Current and Historical Patterns, Total Private Economy

——————— 1969 – 73 (last quarter plotted, II 1973)
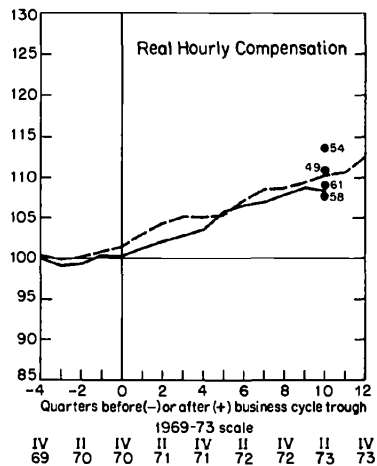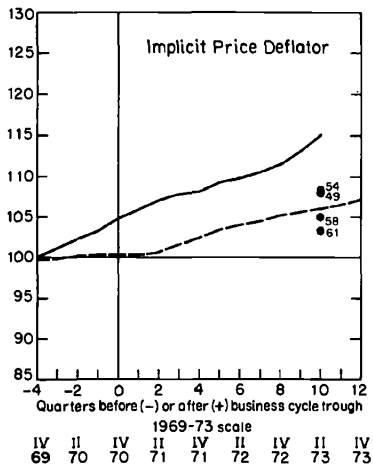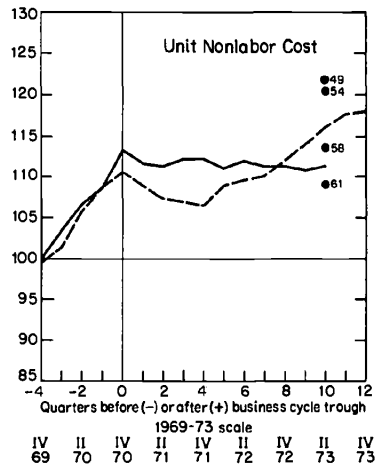
– – – – – – Average 1949 – 63

36
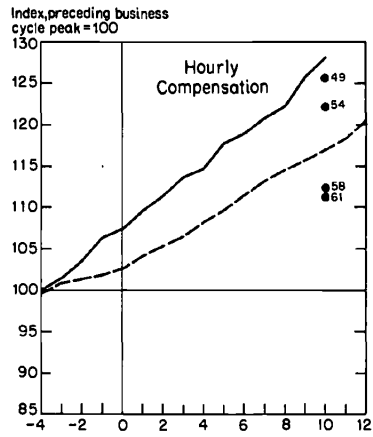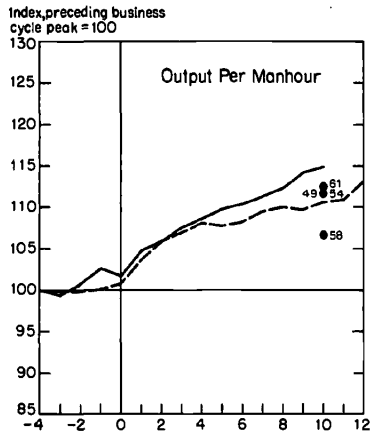
Figure II-3

Expansion Comparisons: Current and Historical Patterns,
Nonfinancial Corporations

——————— 1969 – 73 (last quarter plotted, II 1973)
– – – – – Average 1949–63

Index, preceding business
cycle peak =100

Output Per Manhour

Index, preceding business
cycle peak =100

Hourly Compensation

Unit Labor Cost

Unit Nonlabor Payments

Quarters before(–) or after (+) business cycle trough

Quarters before(–) or after (+) business cycle trough

1969-73 scale

1969-73 scale

| IV 69 | II 70 | IV 70 | II 71 | IV 71 | II 72 | IV 72 | II 73 | IV 73 |

37
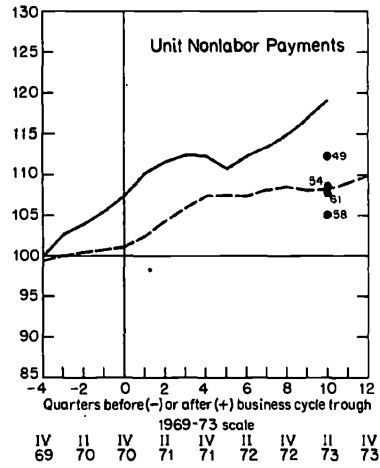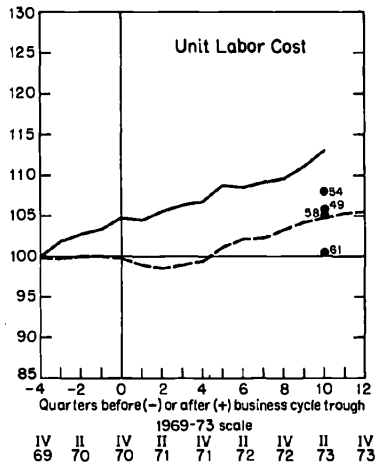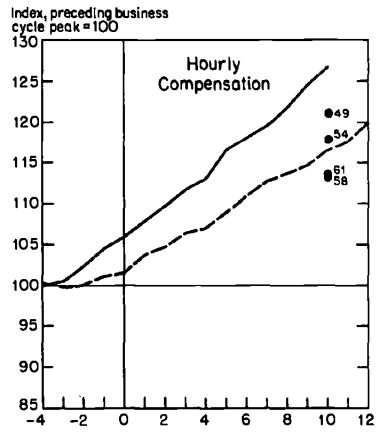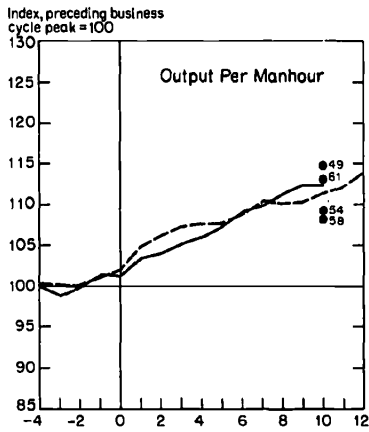
Figure II-3 (continued)

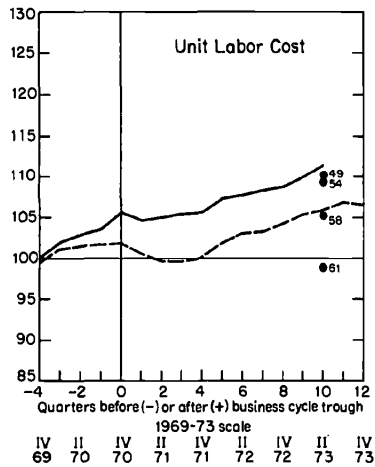———— 1969 – 73 (last quarter plotted, II 1973)
—————— Average 1949 – 63

Index, preceding business cycle peak = 100

Total Unit Cost

Profits Per Unit of Output

Implicit Price Deflator

Real Hourly Compensation

Quarters before (–) or after (+) business cycle trough

1969-73 scale

IV	II	IV	II	IV	II	IV	II	IV
69	70	70	71	71	72	72	73	73

1969-73 scale

IV	II	IV	II	IV	II	IV	II	IV
69	70	70	71	71	72	72	73	73

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Figure II-4

Productivity and Related Measures, Nonfinancial Corporations
(Per Cent Change from Same Quarter Year Ago)

Figure II-5

Rates of Change in Prices and Costs, Nonfinancial Corporations, 1948–73
(Per Cent Change from Same Quarter Year Ago)
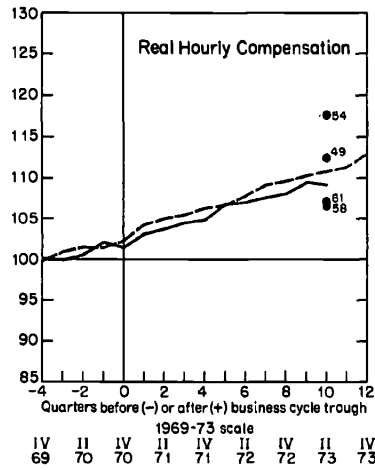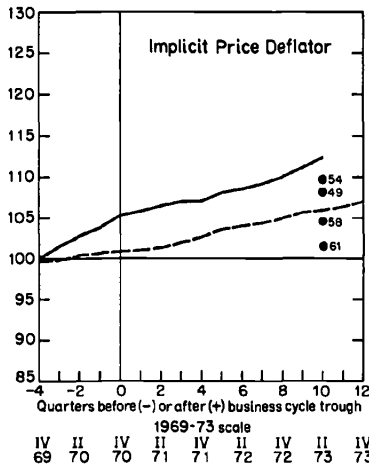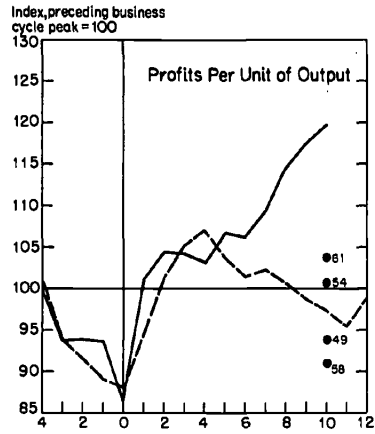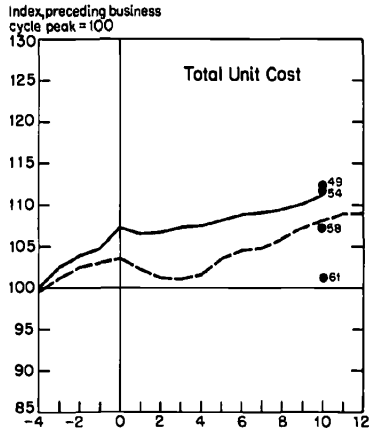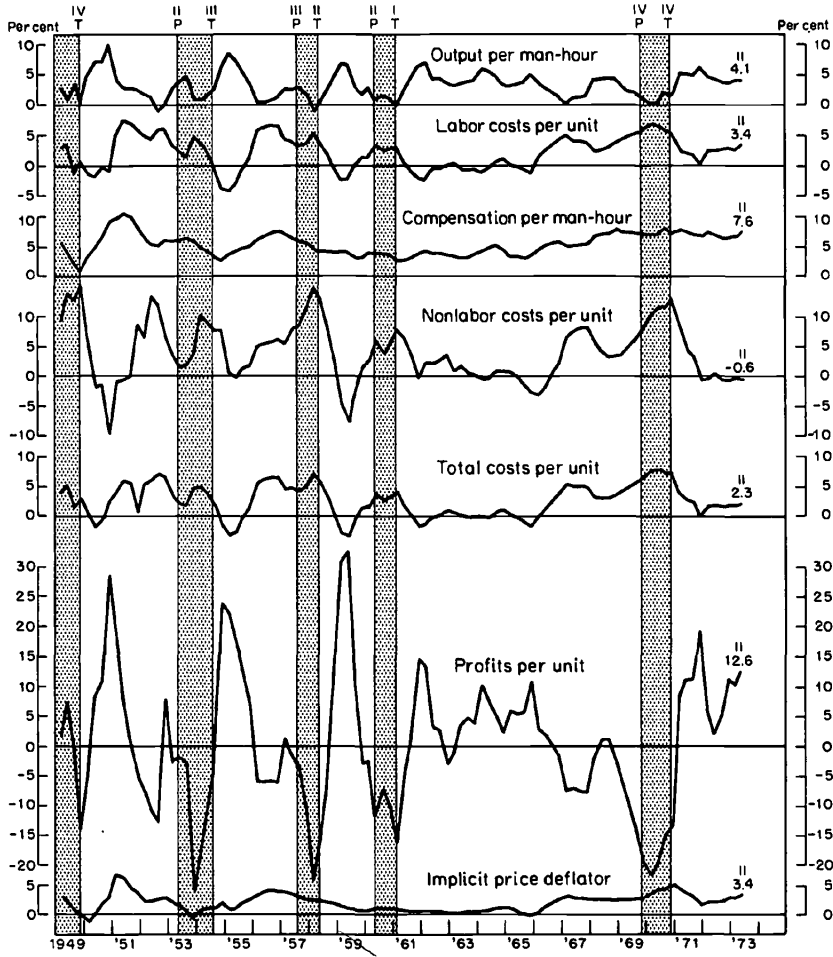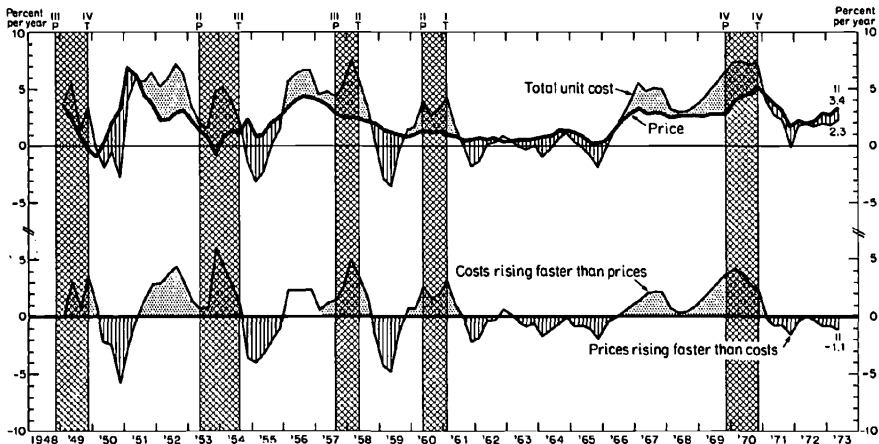
some of the rise in labor costs, so that total unit costs rose no more during the first ten quarters (IV 1970–II 1973) of the most recent expansion than in the average postwar expansion. Profits per unit of output, on the other hand, rose much faster than in the previous expansions, recovering from the seriously depressed level of unit profits in 1969 and 1970.

3. Real hourly compensation — i.e., wages and fringe benefits after allowance for the rise in consumer prices—rose 7 or 8 per cent in the first ten quarters of the latest expansion, compared with 9 per cent for the average of the four previous expansions (Figures II-2 and II-3).

4. The decline in the rate of increase in total costs per unit of output during the latest expansion has been typical of the earlier stages of previous expansions, and so has the more rapid rise in prices than in costs (Figures II-4 and II-5).

5. Slowdowns in economic growth reduce productivity gains but also moderate increases in hourly compensation (partly through reductions in overtime) and in unit labor costs (Figures II-6, II-7, and II-8).

Figure II-7

Average Rate of Change in Hourly Compensation, Private Economy, during Eight Growth Recessions, 1948–70
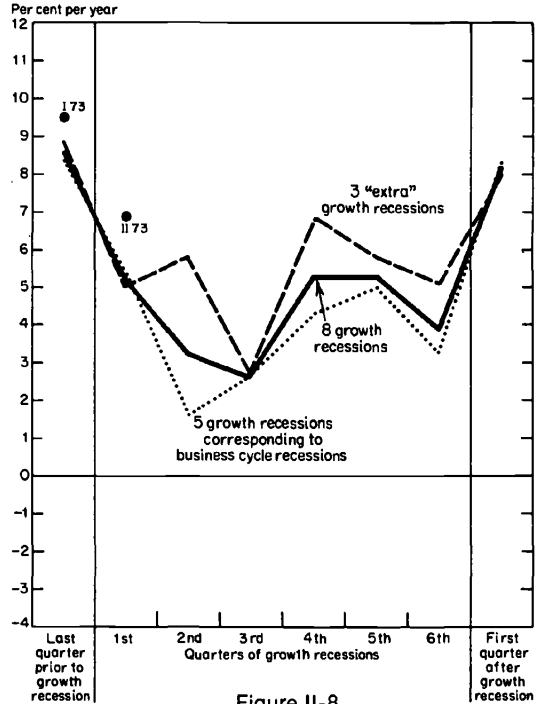
Figure II-6

Average Rate of Growth in Productivity, Private Economy, during Eight Growth Recessions, 1948–70
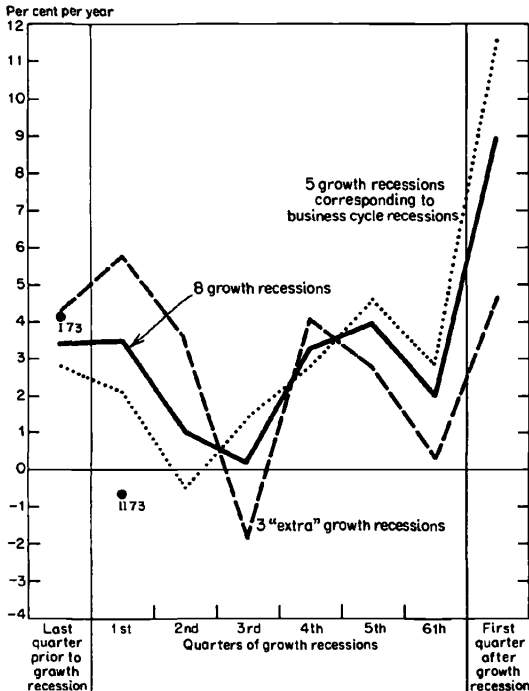
Figure II-8

Average Rate of Change in Unit Labor Cost, Private Economy, during Eight Growth Recessions, 1948–70

40
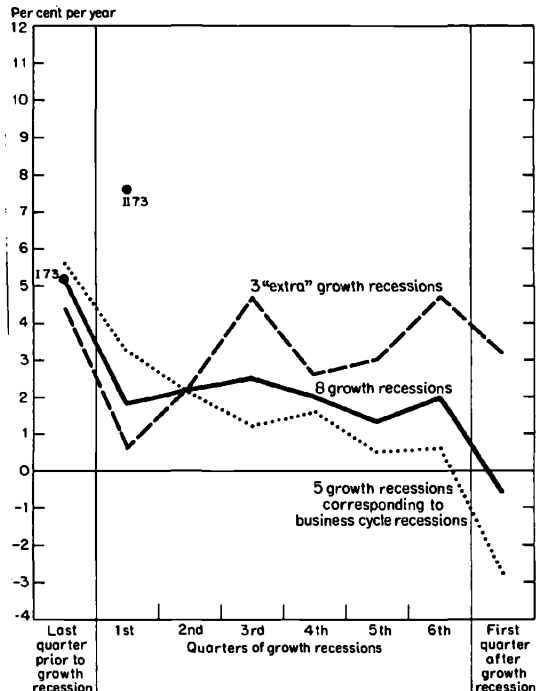
Figure II-9

Long-Run Trends in Productivity, Costs, and Prices,
Total Private Economy, 1947–73

Annual Indexes

Index (1967=100)

Ratio scales

Hourly compensation

Output per manhour

Unit labor cost

Implicit price deflator

Annual Rate of Change

Per cent

Hourly compensation

Output per manhour

Implicit price deflator

Unit labor cost

Five-Year Average
Annual Rate of Change

Per cent

Hourly compensation

Output per manhour

Unit labor cost

Implicit price
deflator

Latest point plotted is the average
change from 1968 to 1973.

Ten-Year Average
Annual Rate of Change

Per cent

Hourly compensation

Output per manhour

Unit labor cost

Implicit price
deflator

Latest point plotted is the average
change from 1963 to 1973.

6. Over periods of five or ten years the rates of increase in hourly compensation have persistently exceeded those in productivity, producing an upward trend in unit labor cost. The increases in prices and costs have been nearly identical, but there has been little relation—if anything an inverse one—between long-run rates of change in prices and profits per unit of output (Figures II-9 and II-10).

7. During 1972 the U.S. competitive position in manufacturing improved dramatically, partly because unit labor costs, especially after taking

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account of the effects of devaluation, rose far less than in other industrial countries (Figure II-11). This improvement continued during 1973. As a result, during the two years 1971–73, labor cost per unit of output in manufacturing, expressed in U.S. dollars, rose only 4 per cent in the United States compared with increases of 48 per cent in West Germany, 42 in France, 42 in Japan, 29 in Italy, 17 in the United Kingdom, and 9 in Canada.

Geoffrey H. Moore

Philip A. Klein

Figure II-10

Long-Run Trends in Productivity, Costs, and Prices,
Nonfinancial Corporations, 1948–73

42
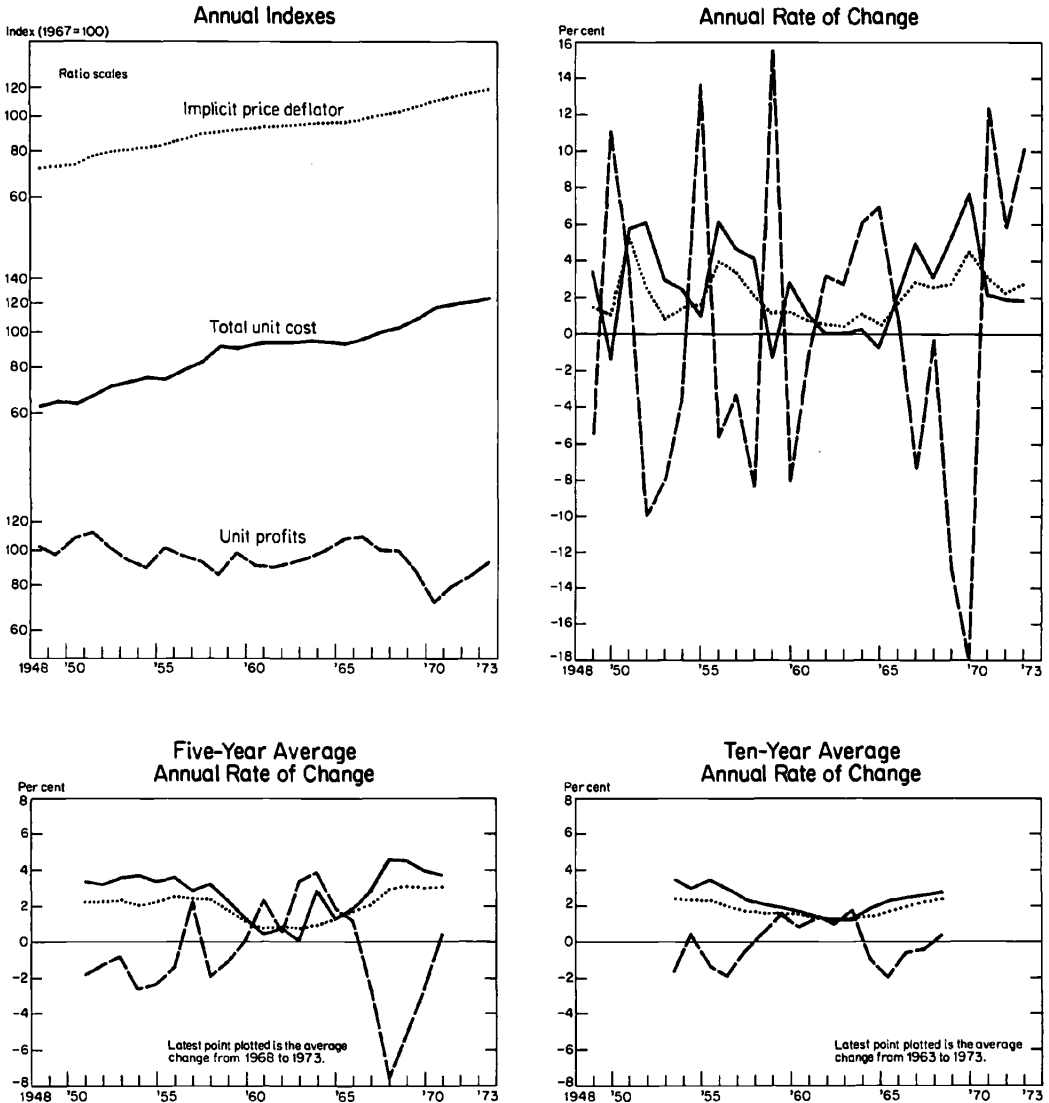
Figure II-11

International Comparisons, 1971–72: Manufacturing

During 1971-72 the increase in hourly wages in every country
exceeded the rise in productivity

Per cent change, 1971-72   Per cent change, 71-72
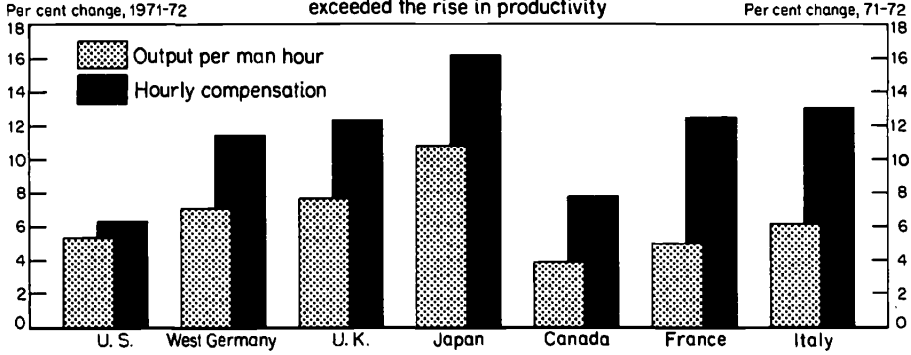
But the difference was smallest in the U. S.,
hence unit labor costs rose less than in any other country
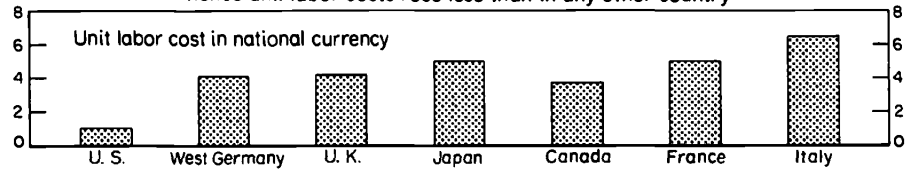
The dollar devaluation greatly increased the U. S. advantage:
in terms of dollars, other countries' costs went up far more than U. S. costs
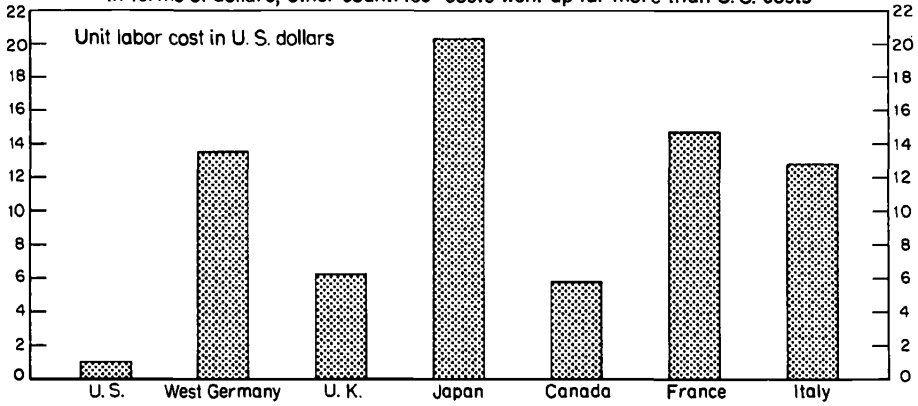
Consumer prices also rose less rapidly in the U. S.
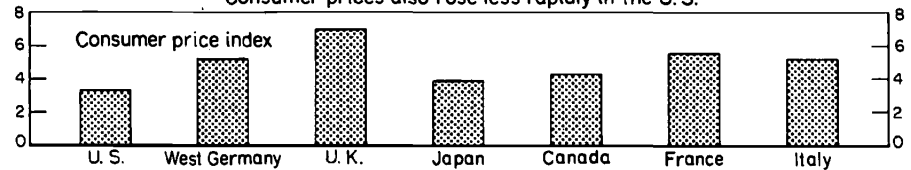
And the increase in real wages corresponded closely to the rise in productivity

43
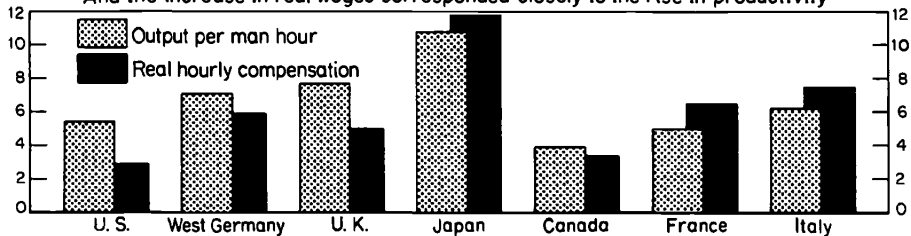
Public Finance

Modeling the Differential Consequences of Alternative Federal Tax, Transfer, and Expenditure Policies

Over the course of the last year our research has proceeded on two parallel fronts. On the first, Stephen Dresch and Robert Goldberg have continued to develop, modify, and elaborate our existing policy analysis model, IDIOM (Income Determination Input-Output Model), described in last year's *Annual Report* and, in more detail, in their paper, "IDIOM: An Inter-Industry, National-Regional Policy Evaluation Model," *Annals of Economic and Social Measurement,* Vol. 2, No. 3 (1973). The model is being specifically adapted to assess the consequences of the current energy shortage and the effectiveness of alternative policies designed to conserve energy utilization. These adaptations of the model are being developed in consultation with the staffs of the Office of Economic Research, Economic Development Administration, and of the Office of Competitive Assessment and Business Policy, U.S. Department of Commerce. Further developments of the model in this area are in progress, with the assistance and participation of interested agencies.

Simultaneously, we are in the process of extending the model as a fundamental research and analysis framework. The extensions currently being pursued, primarily the responsibility of An-loh Lin, and Wu-lang Lee, can be only briefly described here. They will be more fully described by Lin and Lee in a forthcoming paper entitled "A Multi-Regional General Equilibrium Model of Prices and Outputs."

In the experimental model, substitutions between inputs in response to changes in relative factor prices will be incorporated by assuming that each industry maximizes net profits subject to a Cobb-Douglas type production function. Factor demands, including capital services, can then be derived from the marginal productivity conditions. Labor input is disaggregated by occupation. In addition to consumption (treated endogenously in the current model), investment, imports, and exports will be incorporated as endogenous variables. Consumption expenditures will be determined through the personal distribution of factor incomes and transfer payments. Investment expenditures for plant and equipment and for inventories will be separately determined. A neoclassical investment model, of the type developed by Jorgenson and others, coupled with the cash-flow investment theories of Meyer, Kuh, Glauber, et al., will be utilized to determine plant and equipment investment by capital-user industry. The latter will be then transformed into capital-goods purchases by producer industry. Imports will be separated into competitive and noncompetitive components, with the former treated as a component of final demand and the latter as a component of factor demand. Demand for and supply of money functions will be introduced to determine the interest rate. Thus, fiscal as well as monetary policy parameters will be incorporated in the model. Real government expenditures will continue to be exogenous.

In short, outputs, factor demands, consumption, investment, imports, and exports will be functions of relative prices, real wages, the interest rate, real government expenditures, and exogenous parameters. Prices, wages, and the interest rate will then be determined by the requirement that all markets clear—i.e., by the simultaneous equality of demand and supply for each commodity, including the money stock. Given this set of equilibrium prices, outputs, factor employment and income, and final demands will be simultaneously derived.

The regional dimension is currently incorporated in the model via a classification of industries into two groups: national and local. It is then assumed that supply of and demand for the outputs of national industries must balance only within the economy as a whole, whereas local industry supplies and demands must balance within each region. This structural feature of the model will be retained, although it evidently complicates the elaborated version and multiplies the data required for estimation.

In addition to these efforts, final revision and editing of the manuscript by Dresch, Lin, and David Stout, *Substituting a Value Added Tax for the Corporate Income Tax: First Round Price Effects and Their Implications,* has been completed, with the able participation of Ester Moskowitz of the NBER's editorial staff. We an-

ticipate that this study will be published by the end of 1974.

In addition to NBER funds, the public finance research program has continued to receive substantial grant support from the Office of Economic Research of the Economic Development Administration, U.S. Department of Commerce.

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

2. URBAN AND REGIONAL STUDIES

Introduction

There are three major components of the Bureau's research program in Urban and Regional Studies: (1) empirical research on urban housing markets, (2) empirical research on the determinants of industry location, and (3) research to develop a sophisticated computer model of urban housing markets and of other aspects of urban spatial structure for use in the analysis of a variety of public policy issues.

Among the econometric studies of urban housing markets, two manuscripts, Mahlon R. Straszheim's *An Econometric Analysis of the Urban Housing Market* is in press, and John F. Kain's and John M. Quigley's *Housing Markets and Racial Discrimination: A Microeconomic Analysis* has been submitted to the Board for approval for publication.

Straszheim presents an extensive analysis of the demand for housing services in the San Francisco-Oakland metropolitan area using data from a home interview study of roughly 40,000 households. His study, described in last year's *Annual Report,* emphasizes the roles of workplace location, race, and market segmentation on housing demand and on the spatial structure of urban areas. The Kain-Quigley study, which is based on a unique survey of St. Louis households, dwelling units, and neighborhoods, employs a similar theoretical framework and considers many of the same issues as Straszheim. Thus, the two studies strongly complement each other and together greatly increase our understanding of the effects of racial discrimination on urban housing markets.

The concepts developed and tested in the Straszheim and Kain-Quigley studies receive further support from an econometric study of the Pittsburgh housing market by John M. Quigley. Quigley also directly tests a number of the key behavioral assumptions used in the NBER Urban Simulation model. Quigley's manuscript is nearly ready for staff review.

Studies by Weinberg of the mobility of household residences and workplaces and by Straszheim of public sector decision making and the housing market extend the program of housing market research into new areas. Brief descriptions of the Weinberg and Straszheim studies, which are in very preliminary stages, follow.

These various studies of urban housing markets provide the empirical foundations for the Bureau's Urban Simulation Modeling Project. As the discussion of the Bureau modeling work indicates, we have made steady progress toward our long-term goal of developing a model that can be used to evaluate the effectiveness of a wide variety of public policies and programs. The computer simulation modeling program is currently being funded by the Department of Housing and Urban Development. At HUD's request we are currently renegotiating our contract to allow further improvements and modifications of the Bureau model so that it can be used to evaluate housing allowances.

The vitality of the Bureau's research on industry location is evident from the descriptions of these studies that follow. Robert Leone's study of changes in location of manufacturing establishments in the New York metropolitan area and Raymond Struyck and Franklin James' companion study for the Boston, Cleveland, Minneapolis-St. Paul, and Phoenix metropolitan areas should be published in the coming year. Peter Kemper's study, "Determinants of the Location of New Manufacturing Firms," and Roger Schmenner's manuscript, "City Taxes and Industry Location," are now undergoing staff review. Building on these studies, Robert Leone and John Freund have begun a study of changes

in the location of nonmanufacturing establishments, and John R. Meyer and Robert Leone have begun a study of industrial demography using a nationwide sample.

John F. Kain

Simulation of Housing Market Dynamics

In November 1972 we received a two-year contract from the Department of Housing and Urban Development to further develop the NBER Urban Simulation model and to use the improved model to analyze housing abandonment.

As we emphasized in the Detroit Prototype volume, major improvements in the design and calibration of the NBER model were required before we could begin to use it for even tentative analysis of policy issues. The most pressing problem was to improve the econometric estimates of the gross price parameters of the critical submarket demand equations. The estimates used in the Detroit Prototype and Pittsburgh I, the first two versions of the NBER model, were quite unsatisfactory. After a thorough review of alternative approaches, we concluded that the multinomial logit model was the most promising technique for estimating these crucial behavioral relations. Using the multinomial logit, we have estimated a full set of submarket demand equations for Pittsburgh. We have some reservations about both the estimates and the approach, but our preliminary evaluation of them suggests they are reasonable and permit us to further develop the model.

During the more than five years since we began development of the NBER Urban Simulation model, there have been important advances in computer technology. These advances caused us to review the data processing and storage techniques used in the Bureau model. On the basis of this evaluation, we have replaced the summary matrix form of storage used in the Detroit Prototype and Pittsburgh I with a list storage technique. The list storage approach, which maintains information on a sample of households and dwelling units, has major advantages for model design and operation. Specifically, use of list storage greatly reduces the restrictions on model design and permits a more direct mapping from theory to the computer model.

Discussions of both the list storage technique and the use of the multinomial logit for demand estimation are presented in our first interim report to HUD.[1]

We were less than half way through our present contract when HUD asked us to redirect our modeling efforts to evaluate the market effects of a large-scale housing allowance program. Use of the NBER model to analyze housing allowances requires substantial changes in the Bureau model. HUD is particularly concerned with the problem of rent inflation in urban housing markets, a phenomenon that current versions of the NBER model are not well suited to evaluate. We have proposed an amendment of our present HUD contract that would allow us to expand the scale and scope of the model development and to use the improved versions of the NBER model to evaluate both the abandonment problem and housing allowances. The proposed contract amendment, which adds a year to the current contract, would require us to calibrate the improved versions of the NBER model to both Chicago and Pittsburgh.

John F. Kain
William Apgar, Jr.
J. Royce Ginn
Gregory K. Ingram

Local Public Sector Decision Making and the Housing Market

Households at different income levels and stages in the life cycle have distinct preferences for housing and public services. Since changes in demand in the housing market generally tend to occur more rapidly than the residential housing stock can be altered, incomes, housing prices, and composition by family type in different neighborhoods periodically undergo considerable change. This usually implies a change in the demand for public services and in the tax base, since the tax base is primarily determined by the composition of the local housing stock and its prices.

[1] John F. Kain, William C. Apgar, Jr., J. Royce Ginn, and Gregory K. Ingram, *First Interim Report on Contract to Improve the NBER Urban Simulation Model and to Use the Improved Model to Analyze Housing Market Dynamics and Abandonment* (New York, National Bureau of Economic Research, 1973), processed.

This project develops analytic models of adaptation in local public services. Virtually all the existing literature on public sector activity has been static in nature. My model incorporates an objective function reflecting the several different interest groups, including households with and without children, merchants, developers, and local public sector employees. Each of these groups may have different objectives and time horizons. In addition, a variety of constraints on local public sector decisions must be considered, such as tenure and turnover rates in local public sector employment, the existence of a relatively fixed public capital stock, and the inventory of existing housing and vacant land. With so many interests involved in the jurisdiction, specifying an objective necessarily involves the problems of social transitivity, bargaining, and coalition. Nevertheless, incorporation of the constraints, together with a reasonable quantification of the objective function, allows useful inferences to be drawn about local public sector decision making over time. This model, in a simplified form, will hopefully be useful for inclusion in the NBER Urban Simulation model, allowing us to investigate the interdependencies between household location decisions and local public sector activity.

Mahlon Straszheim

Workplace Location Studies

Since 1970 the Bureau has undertaken several workplace location studies using Dun & Bradstreet establishment data. During the past year two studies by Franklin James and Raymond Struyk have been revised to reflect our growing appreciation of the special qualities or particular strengths of this data base, and Leone's original study of manufacturing in the New York metropolitan area from 1967–69 has been extended to 1971. Two other studies are being revised on the basis of staff reviews. The first is a study by Roger Schmenner of Yale University on the impact of city taxes on industry location; the second is a study by Peter Kemper of Swarthmore on the location behavior of new manufacturing establishments in the New York City area.

All of these studies have been limited to manufacturing workplaces and have focused on indi-

vidual cities or sets of metropolitan areas. John R. Meyer and Robert A. Leone have undertaken a broader study of changing patterns of industrial demography. Using this same Dun & Bradstreet data base, changes in the location pattern of manufacturing activity between the years 1967 and 1971 are being examined on a national basis to identify regional, interurban, and urban-rural location shifts as well as intraurban patterns of manufacturing land use. This study has two unique characteristics. First, because it is based on a microdata base, it will be possible for the first time to decompose net location changes on a national basis into their component parts. For example, during the four-year analysis period, nearly 35,000 establishments relocated (exclusive of numerous short-distance moves within the same zip-code area). Approximately 70,000 new manufacturing plants were set up and a comparable number went out of business. The second unique characteristic of the study is that for the first time in a study of national scope, it will be possible to identify location shifts involving analysis zones with subpolitical jurisdictional definitions. For each of the major SMSA's, central industrial districts and industrial enclaves are being defined by examining and aggregating zip-code level data.

A possible companion study of nonmanufacturing workplaces based on a sample of 3 million nonmanufacturing establishments is also being considered (by James L. Freund and Robert A. Leone). This study would cover the period 1971–73 and would share the unique characteristics of the manufacturing location studies.

John R. Meyer
Robert A. Leone

Urban Labor Markets and Public Assistance

My work as a Research Fellow has fallen into three general areas: (1) Production functions in education, (2) The economics of public assistance, and (3) The structure of urban labor markets.

The work on educational production functions has been carried out with my colleague at Michigan State University, Byron Brown. We are currently revising a paper for publication entitled

"The Production and Distribution of Cognitive Skills Within Schools." In this paper, we develop a theory of the school as a multiproduct firm. School authorities have to allocate their resources in order to achieve some optimal distribution of student outputs. Drawing on work that has been done in portfolio theory, we state the theory in terms of the first two moments of the distribution of student performances and we show that under some restrictive but not implausible assumptions, mean student achievement will not depend on the quantity of inputs even if the marginal product of those inputs is positive and even though the variance in achievement will depend on those input levels. Thus, the typical regressions of mean student performance on levels of inputs may well be an irrelevant test of the productivity of those inputs. Then we report some empirical work of our own using Michigan school assessment data that tend to be consistent with our hypotheses.

The work on public assistance is at several different stages. During September I revised my doctoral dissertation *An Econometric Analysis of Aid to Families of Dependent Children in New York City,* for publication by the Industrial Relations Section, Princeton University. This work includes estimates of substitution and income parameters for the labor supply functions of welfare recipients. It turns out that the substitution effects of wage changes are strong whereas the income effects are relatively weak. I have also completed two papers on dynamic aspects of the welfare system. The first paper estimates a stock adjustment model with adaptive expectations. Estimates are based on time-series data on caseloads in the four major categories of the Detroit SMSA, 1962–72. The equilibrium properties of the model are consistent with the economic theory and the dynamic properties, though sensitive to the estimation procedure, are consistent with an assumption of dynamic stability. The second paper examines the probability that a welfare mother will leave the welfare system in any period of time. Estimates are derived from a cross-sectional survey of New York City case records in 1967. The case behavior is consistent with a Markovian assumption about the transition probabilities. This result is basic for undertaking my current project in this area.

I am developing a Markov model in which the states are various welfare and labor market categories. The transition probabilities among states are a function of differing public policies (e.g., different negative tax rates, training, etc.). The problem of finding the least-cost categorical transfer program that will bring everyone up to some prespecified standard of living can then be handled as a dynamic programming problem.[1] As in the case of a discriminating monopsonist, such a categorical program is likely to be cheaper than a general negative income tax scheme. I am currently obtaining data from the New Jersey Negative Income Tax experiments to use for estimating the stochastic matrices required.

Finally, I have been analyzing labor market aspects of the NBER Urban Simulation model. My interest has been in analyzing the way that maximization of expected wages net of commuting costs affects urban structure. The NBER model already generates implicit locational wage rents as the dual shadow prices for the housing assignment problem. To determine how such information affects residential and employment location, it will be necessary to examine the operation of a particular labor market, since the current state of our knowledge in this area is primitive. I am now evaluating data sources for this purpose.

Daniel H. Saks

Industrial Water Consumption

The Bureau has recently completed a two-year study of the impact of rising water costs on industrial water users. The study, supported by the Army Corps of Engineers, attempted to determine how the demand for water affects the technical configuration of water-using processes and their location.

The research was divided into four parts. The first involved examining publicly available information from the U.S. Census of Manufactures Survey of Industrial Water Use. By concentrating on approximately 3,000 establishments in eight four-digit industries that account for over two-

[1] Ronald A. Howard, *Dynamic Programming and Markov Processes* (Cambridge: M.I.T. Press, 1960).

thirds of the nation's industrial water demand, we were able to examine patterns of water use and reuse between the years 1954 and 1968. The primary finding of this analysis was that secular declines in water use per unit output were largely due to increased rates of recirculation. In the absence of recirculation, gross water applied per unit output would generally have remained unchanged or increased slightly.

Our second task was to examine patterns of relocation in water-using industries utilizing Dun & Bradstreet establishment data and capital expenditure and plant expansion information culled from industrial trade journals. On the basis of this admittedly limited data base, we concluded that there was no identifiable tendency for new plants or plant expansion to be associated with water-abundant regions or low-cost water areas. The only consistently discernible pattern involved the rather marked preference for coastal sites or sites along navigable waterways. This led us to the tentative conclusion that water for transportation is at least as important a factor in site selection as is water for processing.

In the light of these findings, we undertook as the third task an examination of possible demand responses to water prices. Using two Cobb-Douglas production functions, one for recycled water and one for final output, we estimated derived demands for intake water and recycled water for the paper, steel, chemical, and petroleum industries, using a cross-sectional sample of price and use data for twenty plants in each industry. To estimate these relations, first it was necessary to impute the difficult-to-separate costs of intake water and recycled water. The inability to make this distinction has hindered prior attempts to measure the price elasticity of water demand. On the basis of these demand estimations, we found that the demand elasticity for industrial water ranged between −0.5 and −1.0. These figures are higher, in absolute value, than those found in most prior work.

The primary reasons for our conflicting results are, first, our reliance on microdata versus more typical aggregate demand estimates; and, second, our willingness to impose theoretical constraints on the limited data, thereby permitting the partitioning of intake and recycled water costs and the estimation of a non-linear production relation. If resources are available, we hope to carry out a comparable time-series analysis of water demand using plant data.

The fourth research task was a survey of the technical literature in each of our studied industries to identify the general thrust of technical change and its likely effects on water use. This survey led us to several generalizations. For example, industries that use water primarily for processing are often forced to make fundamental process changes to accommodate increases in water cost. Since price increases for such industries have in some cases risen from around 1¢ per 1,000 gallons to as high as $1.50 per 1,000 gallons, the need to alter water-use patterns is often a prime investment consideration. Since most of these higher costs are associated with effluent treatment, the water-use decision in industry is typically viewed as a "pollution problem." The same industries, however, often find it economically feasible to treat effluents because of the rising cost of recyclable pollutants contained in the effluent. Rising resource costs ought to accelerate this type of water-use change. Similarly, rising energy costs should encourage greater thermal efficiency and help reduce thermal pollution.

We also found that the rate of industrial water use is highly dependent on technological innovation outside our sample industries. For example, competing container materials have reduced the number of specialty items in a typical paper plant's product line, thereby reducing the substantial water demands associated with the highest grades of paper. We speculated that in the future, changes in solid waste technology will affect the mix of processes in the studied industries. For example, if paper recycling increases, the volume of effluent contaminated in the de-inking process will increase. If, however, scrap paper is recycled as fodder or fuel, as is now feasible in some applications, the input of scrap to paper making might actually decrease, thereby reducing this form of contaminant in waste water.

It is our hope that extensions of these technological surveys would provide a greater insight into the changing pattern of industrial water use.

The final report has been submitted to the Corps of Engineers and two manuscripts are now undergoing review for Bureau publication, one on Water Use in U.S. Manufacturing and another on a Cross-Sectional Model of Industrial Water Use.

Robert Leone
J. Royce Ginn
An-loh Lin

An Analysis of Federal Economic Development Programs

Our research goal is to review the operating and research experiences of federal programs for fostering regional economic development to determine which strategies were effective in achieving program objectives. Although the explicit legislative mandate to effect regional economic development today rests in the Economic Development Administration, the agency sponsoring the research, it is clear that EDA is only one of many federal agencies having an impact on regional and local development.

In formulating our research design, we have assumed that regional development objectives ought to be examined in the context of a national economic growth policy. Unfortunately, national economic growth objectives have not been adequately articulated and offer little guidance to regional policy makers. The concept of "balanced national growth" was intended to allow regional interpretation of growth policy, but to date, the concept has remained undefined and ambiguous.

One view of balanced growth is that which recognizes changing public and private consumption preferences and growing income. This will inevitably lead to the erosion of markets for some products, while advancing technology will inevitably render other products obsolete. The net result will be regional differences in the average rate of economic expansion. Federal attempts to reduce the imbalance in per capita or per family income or some other measure of individual welfare across regions cannot be expected to eliminate the spatial dislocations, nor can it be expected to be effective without in some way having an impact on the local decision-making processes.

In analyzing local development strategies we consider it essential to reconcile the objectives of people versus place prosperity. Regional development policies, by definition, focus on geographic entities. Policy must be concerned with individuals as well, as is recognized by EDA. Conflicts can arise, however. For example, individuals in distressed areas might well be made better off at lower total cost to society through short-term direct income support coupled with incentives to relocate in more prosperous regions. Slower growth, or a reduced economic base for the area, may be a deliberately chosen alternative.

One of our main thrusts is to assess alternative federal roles in local development. For example, how can federal programs overcome the problems of destructive competition among political jurisdictions? Increasingly, communities and even states are adopting "beggar thy neighbor" policies. Federal efforts to encourage more local decision making should avoid cultivating this often destructive competition among political jurisdictions. The well-publicized no-growth objectives of some areas, for example, must be reconciled with the need for the nation to accommodate perhaps 60 million more persons by the year 2000. This population increase will occur even if ZPG birth rates are achieved in the immediate future. Federal actions cannot expect to eliminate the spatial dislocations caused by changing market conditions; they can, however, facilitate regional adjustment to changing economic circumstances. Although this has usually justified federal intervention in distressed areas, there may well be a symmetrical argument for intervention in growing areas to eliminate bottlenecks. Equity considerations, however, may dictate a federal responsibility for distressed areas but not for growing ones.

Identifying social and economic indicators to monitor development policy performance is a primary goal of our research. Such criteria variables should acknowledge the importance of the distribution of income within and among regions, as well as measure the transitional costs of adjusting to changing economic circumstances. Criteria variables, in addition, ought to measure sustainable levels of regional economic welfare and should account for both the disamenities of

development and the amenity value of underdevelopment.

Among the first major activities of the research project was the convening of a conference in Williamsburg, Virginia, on November 30–December 1, 1973, to discuss "New Directions in Federal Economic Development Policy." The conference was under the direction of E. K. Smith and Robert Leone, assisted by Donald Gilmore and Jill Kaiser. Mr. William Blunt, Assistant Secretary for Economic Development, U.S. Department of Commerce, was the dinner speaker on the opening evening of the conference. Mr. Robert Podesta, former Assistant Secretary of Commerce, also addressed the conference. Six papers were commissioned for the two-day meeting covering three broad policy areas: (1) the rationale for continuing federal intervention in local development, (2) a broad perspective on EDA's programs and alternatives to it, and (3) new directions in monitoring policy performance. The papers presented at the conference are now undergoing revision for possible publication.

The six papers, authors, and their affiliations are:

1. "New National Concerns and Regional Policy" by William Alonso, Visiting Fellow at Princeton University, Professor of Regional Planning, University of California at Berkeley.

2. "Re-examining the Case for Federal Involvement in the Market Economy After a Prosperous Decade" by Gordon Cameron, Titular Professor in Applied Economics (Urban Studies), University of Glasgow.

3. "EDA and the Nation's Regional Policy Objectives" by William Miernyk, Professor of Economics and Director, Regional Research Insti-

tute, West Virginia University.

4. "Toward an Alternative EDA Policy" by Niles Hansen, Professor of Economics, Director of the Center for Economic Development, University of Texas.

5. "Evaluating the Impact of Public Policies on Regional Welfare" by Robert Haveman, Professor of Economics, University of Wisconsin; Director, Institute for Research on Poverty, University of Wisconsin.

6. "Welfare Measures for Regional Policies" by William Nordhaus, Professor of Economics, Yale University.

<div align="right">Edward K. Smith
Robert Leone</div>

Mobility of Household Residences and Workplaces

The movement of households within an urban area involves mobility of both residences and workplaces. The model I have developed examines the household mobility decision as influenced by both sociological and economic factors, concentrating on the changes in the levels of independent variables as the cause of a disequilibrium in the household's condition. Previous studies have focused mainly on levels of these variables.

A microdata source, the Bay Area Transportation Study, is presently being analyzed. The data consist of employment, residence, and family histories for ten years, 1955–65, for 3,187 households in the nine-county Bay Area. Detailed mobility analysis is possible because locations are specified by census tract.

No immediate publication is planned.

<div align="right">Daniel H. Weinberg</div>

3. HUMAN BEHAVIOR AND SOCIAL INSTITUTIONS

Introduction

The NBER's Center for Economic Analysis of Human Behavior and Social Institutions is entering its third year with a staff of approximately 40 researchers, research assistants, and secretaries pursuing the various studies summarized

in this chapter. The projects in law and economics are administered by William M. Landes, population and the family by Robert J. Willis, health by Michael Grossman, and the education and information and income distribution programs jointly by Robert T. Michael and Lee A. Lillard.

Overall responsibility for the Center is shared by Victor R. Fuchs, director; Robert T. Michael, associate director; and Gary S. Becker, research policy adviser. The physical headquarters of the Center has shifted to the NBER office in Palo Alto; research activities are carried on in that office, in Chicago, and in New York City.

During the past year two volumes in the NBER series "Studies in Human Behavior and Social Institutions" have appeared: *Schooling, Experience, and Earnings,* by Jacob Mincer (NBER, HBSI No. 2); and *Essays in the Economics of Crime and Punishment,* edited by Gary S. Becker and William M. Landes (NBER, HBSI No. 3). In addition, the second fertility conference held in June 1973 and cosponsored by the Population Council and the NBER resulted in the volume *Marriage, Family Human Capital and Fertility,* edited by Theodore W. Schultz and published as a supplement to the March–April 1974 *Journal of Political Economy.* The two fertility conference volumes are also being republished in a single NBER volume entitled *Economics of the Family: Marriage, Children and Human Capital,* T. W. Schultz, ed. (NBER OC Series No. 10).

Three additional volumes have been approved for publication by the Board of Directors and are currently in press: *Human Capital,* 2nd edition, by Gary S. Becker; *Income Inequality: Regional Analysis within a Human Capital Framework,* by Barry R. Chiswick; and *The Allocation of Time and Goods over the Life Cycle,* by Gilbert R. Ghez and Gary S. Becker. Other volumes proposed for publication, currently undergoing staff review, include *Research, Information, and Agricultural Productivity,* by Robert Evenson and Finis Welch; and *Life Cycle Decision Making: Labor Supply, Investment and Earnings,* by James J. Heckman, Lee A. Lillard, and James P. Smith.

Numerous other research papers and articles by the Center's research staff have appeared in other professional publications. About two dozen discussion papers were included in the Bureau's new NBER Working Paper Series. The authors and titles of these working papers are listed at the end of the staff progress reports.

Victor R. Fuchs
Robert T. Michael

Income Distribution and Education and Information

Introduction

During the past year the National Bureau's Center for Economic Analysis of Human Behavior and Social Institutions has continued to study the determinants of the distribution of employment, earnings, income, and wealth. The recent studies focus on life-cycle aspects of employment behavior aided by the acquisition of several extensive longitudinal data sets such as the National Longitudinal Surveys, the Coleman-Rossi Continuous Work History Sample, and the National Science Foundation's Registry of Scientific Personnel. These data files complement the NBER–TH and Terman data files and several cross-sectional data sets.

Jacob Mincer and his associates, George Borjas, Linda Leighton, and John Owen, report on their work with the first two of these data sets. Yoram Weiss discusses his use of the NSF Scientific Registry in studying occupation choice and career patterns, Lee Lillard and Paul Taubman have extensively examined the earnings functions and implied distributions of earnings or wealth from the NBER–TH sample, and John Hause has used a longitudinal data set from Sweden to study lifetime earnings. James Heckman has, alternatively, used recent cross-sectional surveys as synthetic life histories to study the lifetime profile of the fraction of work-time spent in on-the-job training. The purpose of this research effort is to understand and to estimate the underlying interrelationships among factors such as family background, ability, formal schooling, and labor market experience as determinants of the lifetime patterns of employment and earnings.

Related studies of labor market behavior include Victor Fuchs' analysis of female employment and earnings as well as studies of family earnings and labor supply by Michael Boskin, Lisa Landes, Arleen Leibowitz, and James P. Smith, reported below in the Population and the Family section.

The continuing work on topics in the Education and Information program area include Kenneth Wolpin's analysis of schooling as screening, a complementary study by Kathleen McNally

of determinants of school-completion rates, Isaac Ehrlich's work on the importance of informed decision making in relation to household savings, and Robert Michael's study of the interaction between schooling and ability as factors affecting marital instability.

The National Bureau's involvement in research on education and income distribution topics is not new; a number of NBER research volumes are expected to be published in 1974–75. In addition to the Mincer, Chiswick, Becker, and Ghez-Becker volumes, and the Heckman, Lillard, Smith and Evenson and Welch studies, two NBER–Carnegie Commission on Higher Education books will appear: F. Thomas Juster's *Education, Income, and Human Behavior,* and Paul Taubman and Terence Wales' *Higher Education: An Investment and a Screening Device.* A collection of studies by Lewis Solmon, Paul Wachtel, and Arleen Leibowitz dealing with estimates of the returns to schooling adjusted for the role of school quality and financing rounds out the list. The education and information and the income distribution research programs are funded by the National Science Foundation, the U.S. Department of Labor, the National Institute of Education, and by a program grant from the Rockefeller Foundation.

Lee A. Lillard
Robert T. Michael

The Distribution of Earnings and Human Wealth

This study is concerned with directly predicting or estimating earnings and human wealth distributions using estimated age-earnings functional relationships, and the underlying distribution of age and other characteristics that affect earnings. The statistical distribution theory necessary for this task along with preliminary estimates of earnings and human wealth distributions, both overall and by schooling, ability, and age level for the 1960 census, are presented in NBER Working Paper No. 9. Estimates of earnings and human wealth were based on the NBER–TH sample. The sensitivity of the human wealth distributions to retirement age and discount rate also were estimated.

Predicted distributions of earnings and human wealth have also been obtained for the NBER–TH sample because it is the population on which the earnings estimates were based. These predictions are more detailed and the "fit" between predicted and observed distributions is better than with the 1960 census for reasons discussed in the paper. This research has been expanded to include a discussion of life cycle human capital investment models that specify theoretical constructs under which human wealth (present value of earnings) can be considered an index of economic well-being and under which it cannot. A first attempt is made to indicate what should enter an index of well-being when these conditions are not met. The human wealth distribution estimates are refined to account for the statistical error variation in the estimated earnings function. An estimate of the standard deviation of human wealth is obtained along with upper and lower bounds. The estimated coefficient of variation, a measure of inequality for human wealth, is slightly less than that of earnings. This expanded work was presented at the May 1974 NBER Income and Wealth Conference on "The Distribution of Economic Well-Being."

Lee A. Lillard

The Distribution of Earnings

My volume on the distribution of earnings, *Schooling, Experience, and Earnings,* was published in April of this year. This monograph dealt with the cross-sectional distribution of earnings of men as observed in the 1960 U.S. census. It contains a scheme of analysis derived from human capital theory, which is now being replicated on earnings data in Sweden, Japan, France, and Chile. I gave a report on this kind of analysis at a meeting on the distribution of income, organized by the Royal Economic Society in July 1974 in England.

Progress in the analysis of earnings and income distribution requires data on life-cycle histories of work experience and earnings at the individual level. Such histories have recently become available in surveys that are longitudinal panels and/or retrospective. The NLS (National Longitudinal Surveys) and the NBER–TH are

panels for a few points in the life cycle, with some retrospective information; the Coleman–Rossi sample is fully retrospective, both in work experience and in earnings.

I recently devised a scheme for dealing with work experience histories in the human capital framework. The analysis was implemented on the NLS data for women aged 30–44 in a joint study with S. Polachek. This analysis of earnings of women, which complements the analysis of earnings of men in Schooling, Experience, and Earnings, was also published recently in Marriage, Family Human Capital and Fertility, T. W. Schultz, ed., Journal of Political Economy, March–April Supplement, 1974.

The analysis of work histories is now being applied to estimate an expanded earnings function of men aged 45–59 in the NLS data. Preliminary results, obtained by George Borjas, indicate relations among labor mobility, job stability, and earnings. Lengthy job tenure is associated with heavy investment on the job. Evidently, worker self-investment is strongly related to employer investment in workers. Also, though job mobility apparently enhances earnings at younger ages, it is associated with lesser earnings growth at older ages. The explanatory power of earnings functions that takes account of work histories is significantly greater than that of analysis that utilizes only total work experience in addition to schooling.

The advantage of the Coleman–Rossi sample is the continuity of information on work experience, earnings, and the rich detail of other background variables it contains. Owen and Leighton report on their work during the past six months to adapt the data for efficient computer use. With this work now completed, we are at the stage of programming substantive analysis of earnings, of labor supply, and of effects of ability and of social or family background on both earnings and work experience. Preliminary findings are too fragmentary to report.

Finally, I have returned to an analysis of unemployment effects, as distinguished from employment effects, of minimum wages. This analysis was initiated jointly with M. Hashimoto and was described in the 1971 NBER Annual Report. I have now generalized and expanded the analysis to include the role of coverage, turnover rates, and worker discount rates in the unemployment effects. A draft of the new analysis is now available as NBER Working Paper No. 39.

Jacob Mincer

The Continuous Life Histories

The continuous life histories survey (Coleman–Rossi Retrospective Life History Study) is an unusually rich source of data for the analysis of the determinants of earnings and labor supply. The original survey, a national probability sample, covered 2,000 males in their thirties. Blacks were oversampled, which explains why about 50 per cent of the total sample is nonwhite. A data tape has now been created for this project. The tape contains information on the annual earnings (full time and part time) of each respondent in the year immediately preceding the survey and in the year in which the respondent had eight years of experience; on his weekly hours of work and annual months of employment for each year since the respondent entered the labor force; on his experience before, during, and subsequent to his induction into the armed forces; on the duration and quality of his schooling; on his migration patterns; on his marital and family status; on his measured cognitive ability; and on a variety of indexes of his social-class and religious background.

These data permit improved estimates to be made of the net effect of schooling on earnings and of the way in which schooling and background variables are together responsible for variations in intermediate variables, which in turn influence earnings. (Examples of these intermediate variables include income-increasing job experiences and both hours of work per week and weeks of employment per year.)

Preliminary regressions have been carried out on the earnings function. The remaining regressions on earnings and labor supply functions are now being estimated.

Linda Leighton
John Owen

The Earnings Function and Job Mobility

My research attempts to determine how specific training and job mobility affect earnings. For ex-

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ample, if an employer invests in his employees, he will invest in those individuals whose turnover rates are low. Likewise, an employee who decides to invest time and effort in a particular job will analyze whether or not he will remain in the job long enough to allow a profitable return on the investment.

This framework provides a simple way of introducing job mobility into the earnings function through the expectations hypothesis: there is a functional relationship between on-the-job training and the expected duration of that particular job. Specifically, the model I have worked on this past year indicates that an individual makes expectations about the duration of the ith job, and then decides what the optimal amount of investment for the ith job is. Using this relationship, I have expanded the basic earnings function. The model shows that the usual interpretation of the linear coefficients of experience as the initial investment ratios is no longer valid. These coefficients underestimate the actual investment in all jobs except the current one.

The analysis of these aspects of labor-market behavior is made possible by information on individuals' lifetime work histories. I have tested the model on the 1966 National Longitudinal Survey for Mature Men, aged 45–59. This data set provides extensive (though retrospective) information on the job histories of these individuals.

The preliminary empirical results support the expectations hypothesis: it is optimal for an individual to invest on the job according to how long he expects to stay at that job. In fact, the results suggest that there is a large and significant amount of specific training in human capital investment, strong enough to influence an individual's investment decision on the ith job.

A large proportion of these men first entered the labor force in the early years of the depression of the thirties. The empirical results suggest that very little investment was made in short-term jobs during the 1930s. Indeed, these results are consistent with optimal investment theory. For obvious reasons, neither employees nor employers had incentives to invest at the time.

I am presently working on the implications of the expectations model for changes in earnings over time. Again, the NLS data set will prove useful since it provides information over a five-year span of the earnings profile.

George Borjas

Ability, Schooling, and Earnings Over the Life Cycle and Human Wealth

In this study I am concerned with the implications of a lifetime rather than a single period as the unit of analysis regarding economic decisions about investment in human capital. The empirical estimation focuses on age, ability, schooling, and earnings relationships. My earlier work "An Explicit Solution to the Human Capital Life Cycle of Earnings Model and Estimation," is currently under review and will appear in the NBER volume *Life Cycle Decision Making: Labor Supply, Investment and Earnings.* This work is currently being extended to relax the assumption of homogeneous human capital to include the possibility of several types of human capital, each with its own rental rate and its own reproduction capabilities. Since human capital is embodied in the individual, all types of human capital accompany the individual in all his or her activities. Thus, investment decisions cannot be separated for each separate type of capital. Individuals may differ in their ability to produce different types of human capital. Different occupations presumably require different mixes of various types of human capital.

The primary objective of my current research is to understand how various dimensions of ability influence schooling, occupational choice, and earnings over the life cycle. Several ability measures are available in the NBER–TH sample, from reading comprehension and numerical operations to finger dexterity. I am studying the influence of these various ability measures on schooling decisions and on subsequent earnings. In the empirical work, I consider the role of social and family background variables as determinants of the various ability measures and the usefulness of principal components in synthesizing these many ability measures. Second, I consider the effect of the various ability measures and/or synthesized factors and social background variables as determinants of years of schooling. Third, I consider the role of schooling, ability, and social background varia-

bles as determinants of earnings over the life cycle, earnings as a function of age or experience. This approach accounts for the simultaneity of schooling and earnings that is predicted by the theoretical life-cycle model.

Lee A. Lillard

Sources and Inequality in Earnings

I have been reestimating earnings functions using the NBER–TH data set to try to find the types of skills—cognitive and noncognitive—that affect earnings and the types of nonpecuniary job characteristics for which compensating differences in monetary rewards are paid. In the first problem I have focused on the differential effects of various family environments. I have found, for example, that Jews earn up to 40 per cent more than nonJews in comparable jobs, even after including variables for M.D., L.L.D., and self-employment assets. I also have found how time spent in childhood is related to earnings.

I have studied the nonpecuniary trade-offs by including answers to questions on whether certain factors were present when an individual entered his occupation. It appears, for example, that characteristics such as risk aversion, helping others, and the independence and challenge of work are traded-off against monetary earnings.

The variables used to measure preferences have been subjected to some validation tests, but additional work is clearly required on the meaning and precision of these variables.

The sample is not a random drawing of the population; thus the results may not generalize to the population at large. In this sample several family environment and nonpecuniary variables have a stronger effect on the range and variance of earnings than has education. Few of the variables considered have an impact on the skewness of the distribution of earnings.

Much research on human capital has started from a simple model in which people invest rationally. This model has been used to generate certain equations and hypotheses, which unfortunately, are too vague to be tested or depend on parameters of nonmeasured variables. By making use of some of the dynamic predictions of Mincer's theory of on-the-job training, I have

been able to test certain classes of his models. The data are not in accord with his predictions for these cases.

A lengthy paper on these topics was presented at an NBER Income and Wealth conference in May 1974. A shorter version was given at a conference of the Royal Economic Society in England this summer.

Paul J. Taubman

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

An NBER working paper (No. 25) bearing this title was completed in December 1973. The paper develops and empirically tests the implications of the simple earnings function $x_t = m + wt + u_t$ for interpreting longitudinal earnings data in studying the potential empirical significance of earnings differentials generated by different levels of on-the-job training (OJT). In this equation, time (t) is set to zero at Jacob Mincer's "crossover" period, x_t represents earnings at period t, m equals the level of earnings at crossover (in the absence of u_t) owing to differential ability, w equals the slope of the earnings profile, and u_t is a stochastic earnings component. This framework is used to examine OJT effects in two ways.

First, differences in the slopes of the earnings profiles, w, across individuals may not stem entirely from OJT, but such differences provide a reasonable upper bound estimate of the importance of OJT in generating different rates of growth of earnings. I have developed several methods of estimating the standard deviation of w across individuals. Calculations with a sample of Swedish elementary school graduates with seven years of income data led to the conclusion that a 1 standard deviation differential in w over a five-year period would lead to an income differential of about 22 per cent of mean income at age 26, a sizable effect.

Second, an analysis of the partial correlation of earnings for three years, r_{ikj}, with $i < j < k$ with the assumed earnings function for x_t, leads me to the conclusion that the partial correlation would be negative in the absence of u_t. If u_t can be represented 'as the sum of a random walk and a purely transitory earnings variation, only

the OJT component of the model would lead to a negative partial correlation. I am unaware of any other seriously proposed theory of the earnings profile that would lead one to expect a negative partial correlation of earnings. The application of this test to several samples led to erratic results for some Swedish data, but a sample of recalled full-time earnings data derived by D. C. Rogers provided modest support for the hypothesis of negative partial correlations.

This work indicates the importance of longitudinal data for studying OJT and the fruitfulness of systematic study of the covariance structure of earnings for understanding and interpreting the evolution of the earnings profile.

John C. Hause

Women in the Labor Market

I am continuing to examine various aspects of the role of women in the labor market, including the female-male differential in earnings, occupational segregation, and female labor-force participation rates.

I presented a paper, "Recent Trends and Long-Run Prospects for Female Earnings" (NBER Working Paper No. 20), at the American Economic Association meetings in December 1973. It was published in the AEA *Proceedings,* May 1974. An excerpt was published in the *Monthly Labor Review.* This paper presents estimates of hourly earnings for white women and men for 1959 and 1969 calculated from 1/1,000 samples of the 1960 and 1970 U.S. censuses of population. The relative earnings of women (adjusted for age and schooling) improved over the decade despite an unprecedented increase in female employment. The decrease in the sex differential in earnings was particularly large for workers with more than twelve years of schooling. This decline is explained by the rapid growth of industries, such as health and education, that employ large numbers of well-educated women and by differential shifts in labor supply.

An index of occupational segregation of white women and men, calculated from the census samples, indicates a substantial decrease for persons under 35 with more than twelve years

of schooling. The other age-schooling groups showed slight increases in the index, but these rises could be explained by the increase in occupational detail between 1960 and 1970. The increased acceptance of women in a variety of labor-market roles and their more continuous attachment to the labor force are important factors affecting their relative earnings.

A preliminary attempt to analyze female labor-force participation reveals a significant cohort effect that is closely related to fertility. Women born around 1910 have exhibited consistently higher labor-force participation rates than the rates predicted by secular trends and average age profiles. The participation of those born in the early and mid-1930s has been lower than predicted. The inverse correlation with the cohort fertility pattern is striking.

Victor R. Fuchs

The Distribution of Income

Income Inequality: Regional Analysis Within a Human Capital Framework is in press as an NBER volume. The book explores the theoretical and empirical relationships between regional differences in the level and inequality of income and regional differences in investment in human capital (schooling and post-school training) and the rate of return on these investments. Data for the United States, Canada, and several other countries are used in the empirical analysis. The 1973 *Annual Report* contains a detailed discussion of the book's methodology and findings.

One byproduct of my research on income distribution is "Racial Discrimination in the Labor Market: A Test of Alternative Hypotheses," *Journal of Political Economy* (November–December 1973), reprinted in G. von Furstenberg et al., eds., *Patterns of Racial Discrimination,* Vol. II, *Employment and Income* (Boston: D. C. Heath, Lexington Books, 1974). This article develops procedures for empirically testing alternative hypotheses about labor-market discrimination. The application of the tests indicates that 1960 data for the United States are consistent with the hypothesis that white male workers discriminate against working with black males.

Another byproduct is "Racial Differences in the Variance in Rates of Return from Schooling,"

in von Furstenberg *et al.*, *Patterns of Racial Discrimination*. This article indicates that black males appear to have a larger variance and co-efficient of variation in rates of return from schooling than white males. Much of this larger variation in rates of return is owing to a greater uncertainty about employment (weeks of work) during the year for black males. A greater uncertainty of returns may, in part, explain lower human capital investments by blacks.

Barry R. Chiswick

Schooling as Screening

A primary focus of the research in human capital has been the education-income relationship. Calculations of rates of return to schooling have generally yielded estimates well within the range of the return on alternative physical investments. Recently, however, questions have been raised concerning the nature of this relationship. Education can be viewed as enhancing productivity and also conveying low-cost information to employers about the productive capabilities of prospective workers. The investment in schooling may serve to augment one's skills or to identify oneself as a more productive employee, or both. So the private return to schooling is the sum of two distinct components, one the result of the increment in productivity caused by the schooling process, and one the result of the information conveyed by the achievement of a certain level of schooling.

The model I have developed explores the impact of uncertainty about labor quality on the demand for labor services. Within an expected profit maximization framework, firms are shown to pay a premium to workers with greater skills and to those whose skills are known more precisely. If additional schooling sorts individuals into finer and finer skill groupings or if firms are simply more certain about the average skill level of more highly educated groups, then there will be an increase in the private return on the schooling investment over and above that which results from actual productivity differences.

The model also has implications for the social desirability of educational investments. The use of education as a screen can be shown to increase allocation efficiency and thus the output of society. Private and social benefits from education may diverge depending on the mix of education's productivity-enhancing effect and its informational content.

I have performed several tests formulated to demonstrate the existence of educational screening. For example, I have attempted to discern a positive "variance-effect" on the relative wages of the more highly educated. The basis for these tests stems from the fact that employer-perceived differences in productivity tend to erode over time as information about an individual's productivity is gleaned from on-the-job performance. Using the NBER–TH sample (a longitudinal survey of approximately 5,000 Air Force pilot and navigator candidates in 1943 with reported income histories through 1970), I have estimated life-cycle earnings profiles. It appears that post-school investment behavior tends to overwhelm whatever variance effect exists. I am attempting to refine this test to distinguish the post-school investment effect and the variance effect.

Another test of the screening hypothesis is related to the correlation between earnings and schooling at different stages in the life cycle. At early stages the correlation is expected to be high (i.e., the variation in earnings is expected to be small within schooling groups since initial earnings are based on group identification). At a later stage in the life cycle the correlation is expected to be weaker, since individual differences in productivity, previously unknown to firms, begin to emerge, leading to increased variation in earnings within schooling groups. Moreover, if increased expenditures on education over time have enhanced screening efficiency, the within-group variation in earnings should be smaller for newer cohorts at each stage of the life cycle. To test these implications, I will use several cross-sectional data sets.

Ken Wolpin

Determinants of High School and College Completion Rates

In this study I seek to identify those characteristics that enable us to distinguish among three groups involved in the educational process: (1) drop-outs, (2) those who complete a given

level of education and terminate their formal training, and (3) those who complete and continue their education. The framework of school organization is such that an education is received in certain steps (credentials, diplomas, or degrees). Because the acquisition of human capital is a continuous process, schooling could, in principle, be carried out under one continuous organization. The inherent lumpiness in the traditional educational structure, however, together with the nonlinear effect of credentials on earnings (as observed in most rate of return studies) makes these credential points an interesting frame of reference.

I have developed a statistical model for estimating probabilities of high school and college completion as related to student characteristics and the quality of the educational system. Using the young men and young women samples of the National Longitudinal Surveys, my empirical research will focus on the study of incentives to drop-out prior to completion; the effects of part-time earnings on drop-out rates; the significance of quality of the high school attended as it affects completion and subsequent credentials; and the importance of sex, race, academic ability, and family background as distinguishing characteristics. Although the two data sets under study are not strictly comparable, the parallel structure of the male and female questionnaires will allow for substantial comparative analysis between the two groups.

Kathleen V. McNally

A Theory of Productive Saving

Considerable attention has been paid in the economic literature to the magnitude of personal savings: the excess of current income over expenditures on current consumption or, alternatively, the net accumulation of physical capital assets that are ultimately used to finance some future consumption or bequest. Very little attention, however, has been given to the process of saving itself—the generation of nonwage income through the productive employment of the accumulated stock of capital assets. Such activity generally has been thought of as a neutral process in the sense of not claiming the use of scarce resources, or, at least, being independ-

ent of the amount of resources forgone in its pursuit.

The central thesis of this study, which I am conducting in collaboration with Uri Ben-Zion, is that the selection of optimal portfolios incorporating financial and real capital assets and their adjustment to actual and anticipated variations in market conditions as well as to the level of human capital—the activity of saving—does involve the use of time and other resources in searching for, collecting, interpreting, and applying relevant information. Indeed, the development and rapid growth of investment funds, portfolio managers, and financial or investment specialists provide some indirect support for the validity of this postulate even in the largely centralized financial markets, for these institutions enable individual investors to substitute the time of specialized agents for part of their own time and effort. The returns to search and superior management may be even more significant in the case of investments in less homogeneous capital assets, such as real estate, that are transacted in dispersed and largely segmented markets. Clearly, information regarding the productivity of assets is neither full nor free and portfolio management may involve considerable transaction costs. In view of these considerations, it may be conjectured that the overall amount of nonwage income derived from a given investment—the rate of return on physical capital—is, at least in part, an increasing function of the amount of one's own time and other resources devoted to saving, as well as of one's specific human capital.

This apparently simple hypothesis, along with some restrictive assumptions regarding the nature of the utility of lifetime consumption and the production function of nonwage earnings, leads to a number of novel and testable implications. Specifically, it suggests that variations in hours of work can be deduced, in part, from variations in factors determining the extent of participation in saving activities. More important, it suggests that the magnitude of individuals' savings may depend on the extent of their participation in and productivity at saving activities. A general theory of savings, then, should deal directly with the interdependencies between consumption and savings decisions on the one hand, and the allo-

cation of individuals' time between work and saving, as well as other productive pursuits, on the other.

In this paper, I use the productive saving hypothesis to derive a systematic relation between the propensity to save and wealth that rephrases and modifies Keynes' second law of consumption. We also use this approach to reinterpret in light of theoretical expectations cross-sectional and time-series evidence on the relation between income and savings, and to derive behavioral implications concerning life-cycle patterns of capital accumulation and the allocation of productive time between work and saving activities. I am now in the process of testing the major implications of our model against empirical data available from the Federal Reserve sponsored Survey of Financial Characteristics of Consumers (1962) and Survey of Changes in Family Finances (1963), which were conducted by Dorothy Projector and Gertrude Weiss.

Although the main concern in this paper is with physical capital, the theory is applicable to both physical and human capital. My future plan is to expand the model developed in this paper and to deal with the interdependencies between physical and human capital.

Isaac Ehrlich

Education and Marital Behavior

Schooling is frequently observed to be highly correlated with individual characteristics such as earning power, health, geographical mobility, fertility, and marital status. Some authorities argue that these correlations do not result from the direct influence of schooling on behavior but rather from the influence of some third factor that is highly correlated with schooling. For example, innate intelligence and parental wealth are highly correlated with one's level of schooling, and it has been argued that the positive relationship between schooling and hourly wages may simply reflect the greater ability or parental wealth of more highly educated workers.

This issue is of considerable importance when schooling is viewed as a mechanism for enhancing one's productive capacity and well-being. If schooling functions only as an index of genetic or early childhood environmental factors, then

schooling may not be the appropriate vehicle for improving one's circumstances. If, however, schooling provides useful skills and knowledge and alters one's capacities and attitudes, then schooling may itself influence behavior independently of (or interactively with) native ability, childhood environment, and other factors.

One of the purposes of my study of the marital patterns of the Terman sample of geniuses is to determine whether formal schooling affects the marital behavior of these high-I.Q. men and women in the same way that it affects the marital behavior of the population at large. If so, we can be more certain that the correlations between schooling and marital patterns in the general population are not simply a reflection of the influence of I.Q. on marital behavior.

Evidence from the U.S. census of the population in 1960, more recent Current Population Surveys, the 1967 Survey of Economic Opportunity, and the 1965 and 1970 National Fertility Surveys suggest that more highly educated men and women marry at later ages. Furthermore, nearly all U.S. cross-sectional surveys indicate statistically significant positive correlations between the level of schooling of spouses—more highly educated individuals tend to select relatively more highly educated mates. There is also evidence that among women, higher levels of schooling are associated with relatively lower marriage rates.

My study of the Terman sample tentatively suggests:

1. Schooling affects marital behavior among these exceptionally high-I.Q. individuals in the same qualitative manner as it affects marital behavior in the population at large. The more highly educated marry at a later age, are maritally more stable, and marry relatively more highly educated mates. Among women, the more highly educated have a lower incidence of marriage. So the correlations between schooling and marital behavior in the population would not appear to reflect simply the influence of I.Q.

2. On an age-, cohort-, and an education-adjusted basis, the Terman sample exhibits a greater incidence of marriage and divorce than does the population at large. The Terman subjects marry at a relatively young age, given their level of schooling, and they subsequently di-

vorce at a relatively high rate.

I presented a paper on this research, "An Analysis of Factors Affecting Marital Instability: A Preliminary Report," at the June 1974 meeting of the Western Economic Association. I plan to collaborate with Gary Becker and Lisa Landes in studying the marital behavior in the SRC's Income Dynamics Panel data and in the Coleman–Rossi retrospective life history data.

Robert T. Michael

The Quantity and Quality of Educational Attainment

Lewis Solmon and I have, for several years, been studying the influence of high school and college quality on lifetime earnings patterns. Although still tentative, our results indicate that quality differences—measured as various characteristics of schools—have strong and lasting effects on earnings. Several papers have emerged from this project. They include:

L. Solmon and P. Wachtel, "The Effect on Income of Type of College Attended," forthcoming in *Sociology of Education,* available as NBER Working Paper No. 14.

P. Wachtel, "The Returns to Investments in Higher Education—Another View," forthcoming in *Education, Income and Human Behavior,* ed. F. T. Juster, Carnegie Commission on Higher Education and NBER, 1974.

P. Wachtel, "A Note on the Interaction of Schooling and Ability," NYU–GBA Working Paper No. 73–33.

L. Solmon, "The Definition and Impact of College Quality," NBER Working Paper No. 7.

P. Wachtel, "The Effect of School Quality on Achievement, Attainment, and Lifetime Earnings," in preparation.

These various studies are being revised for Bureau publication. Some of the results have been described in previous reports, so that only the progress of the past year will be summarized. Currently, planning is underway for specific studies of the educational production process using several data sets with longitudinal information on student performance.

In my paper, "The Effect of School Quality on Achievement, Attainment, and Lifetime Earn-

ings," I examine the effect of pre-secondary school quality on levels of achievement, amounts of secondary schooling attained, and lifetime earnings. The model relating school quality and background variables to the three outputs is recursive. The basic conclusion that emerges from this study is that school quality matters, a conclusion that contradicts a growing sentiment among social researchers that schooling is of little consequence.

The results, from an analysis of the NBER–TH data, suggest that school quality has a strong direct effect on achievement levels (achievement scores based on Army tests in 1943) and on earnings. The direct effect of quality on earnings at mid-life appears to be as strong as the effect of father's education. The effect of quality on earnings appears to be a direct one, with only about 10 per cent of the effect flowing through measured achievement.

Although the results do suggest that school quality has a significant effect on earnings, they do not imply that higher-quality schooling can substitute for additional years of schooling. An additional year of college increased 1969 earnings by an average of 6.4 per cent in this sample. An increase in per student institutional expenditures of $43 in 1939 would have had an equivalent effect on 1969 earnings. This represents almost two-thirds of the average expenditure level and close to twice the interstate standard deviation in expenditures.

In "A Note on the Interaction of Schooling and Ability," I conclude that although there are strong theoretical arguments for the existence of an interaction between schooling level and measured ability, there is very little statistical evidence of an interaction effect in the NBER–TH data. Although the statistical tests indicate that the overall interaction effects are not significant, they do exist. In fact, some of them are fairly strong. For example, the predicted difference in mean earnings between high school graduates and those with some post-graduate study is $4,130. When an interaction is allowed for, the predicted differences range from $3,000 for the lowest-ability quartile to $5,540 for the highest.

Most studies of the returns from schooling ignore cost differences among schools, usually because the requisite data are not available. If

cost differences among schools are correlated with the earnings of graduates, then previous estimates of the rate of return are biased. My study, "The Return to Investments in Higher Education—Another View," discussed in last year's *Annual Report,* uses school-specific cost and expenditure data to estimate returns. The study shows that estimates of return that ignore institutional differences in expenditures and tuition are biased upward about 10 to 15 per cent because of the tendency of students with higher earnings potentials to make more expensive investments.

I have completed some additional work on this study since submitting the paper for publication in the Carnegie Commission–NBER volume listed at the beginning of this report. The new results include:

1. The social return from public education is about half the social return from private schooling at both the graduate and undergraduate levels.

2. Even if the tuition subsidies of public colleges are considered (i.e., the private return), the return from private schooling is larger.

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

Life-Cycle Decision Making: Labor Supply, Investment, and Earnings

The proposed NBER volume carrying this title will contain separate essays by the three of us; the manuscript is now being reviewed. The first essay, by James Smith, focuses on family decisions on labor supply over the life cycle. 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 in economic decisions.

Smith tests the model 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 on three educational 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.

The second essay, by James Heckman, deals with a variety of decisions over the life cycle, including behavior regarding labor supply, consumption, and asset formation. Heckman's 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 occupations with different training contents are selected over the life cycle.

In the first section of his 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.

In the second section he estimates the theoretical models using a cross-sectional average life-cycle profile over consumers (a synthetic cohort approach). In the study he presents estimates of 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. These estimates he uses 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 third essay, "An Explicit Solution to the Human Capital Life Cycle of Earnings Model and Its Application to Earnings Distributions," is by Lee Lillard. Lillard derives implications from an explicit solution to the life-cycle human capital model for age-earnings profiles and investment behavior over the life cycle and also explores the implications for earnings distributions. 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. Lillard emphasizes that the earnings profile and length of full-time schooling are determined simultaneously. 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 are a national sample of male high school sophomores who in 1955 were given achievement tests and answered a follow-up survey in 1970.) The age-earnings profiles estimated from the NBER–TH data are then used to predict human wealth, defined as the present value of earnings over the working life.

James J. Heckman
Lee A. Lillard
James P. Smith

Earnings and Career Patterns of Scientists

My study consists of an empirical analysis of the longitudinal file of the National Science Foundation's National Register of Scientific and Technical Personnel. About 90,000 scientists reported their earnings in 1960, 1962, 1964, 1966, 1968, and 1970. The surveys contain information on the characteristics of their work and on the nature of their experience in each of these years. Additional background data on education and place of birth are also available. I am using this data set to test implications from the human capital investment model.

Assuming optimal investment behavior, I derived two types of autoregressive schemes. One is a linear dependence of current earnings on four lagged values. In the second version the log of current earnings is a quadratic function of the logs of two lagged values. The optimization hypothesis yields restrictions on the parameters, which can be tested. The basic advantage of this approach to longitudinal data is that many specific effects on earnings (such as ability and vintage effects) drop from the earnings equations. A limitation of this approach is the difficulty in controlling for exogenous changes that occurred during the period of time under investigation.

Other questions that I plan to analyze include:
1. A comparison of cross-sectional (ex-

pected) earnings to actual (historical) earnings profiles.

2. The effects of initial conditions (e.g., starting salaries) on the development of earnings over years. We plan to use a Markovian scheme for this analysis.

3. Labor mobility and its relation to the development of earnings for various age groups over the period 1960–70.

4. Differences in variability in the current and ten-year averages of income in various occupations and types of work.

Yoram Weiss

Law and Economics

Introduction

Several studies that were described in detail in previous annual reports have been completed during the past year. They include a theoretical analysis of law enforcement by Gary S. Becker and George J. Stigler (which has been published in the Journal of Legal Studies, January 1974), a theoretical and empirical analysis of the deterrent effect of capital punishment by Isaac Ehrlich (which will appear in the American Economic Review), and an economic analysis of legal procedure and judicial administration by Richard A. Posner (which appeared in the Journal of Legal Studies, June 1973). A collection of essays entitled Essays in the Economics of Crime and Punishment (edited by Becker and William M. Landes) was published this summer. This volume contains essays on law enforcement by Becker, Ehrlich, Landes, Posner, and Stigler. Ehrlich and Posner have also completed a paper, described below, on the economics of legal rules (which has been published in the Journal of Legal Studies, January 1974).

Additional research, which is described in more detail in the individual reports below, include the following: Ehrlich's analysis of the time trend of crime in the U.S., which extends his earlier work on capital punishment and deterrence; Landes' studies of criminal court procedure and the demand for civil litigation; Posner's study of the costs and benefits of delay in adjudication in administrative agencies; Melvin Reder's analysis of optimal law enforce-

ment that incorporates the rights of citizens (e.g., free speech); Stigler's study of the sources of economic legislation; and Ann Bartel's study of private protection against crime. The law and economics program is being supported by a grant from the National Science Foundation.

William M. Landes

The Time Trend of Crime

I have completed a draft of a paper titled "The Deterrent Effect of Capital Punishment: A Question of Life and Death" that investigates the impact of punishment by execution and a number of other variables on the time trend of murder in the United States from 1933 to 1969. A short version of this paper will be published in the *American Economic Review*, and a more extended version, augmented by new evidence based on cross-sectional data and by a fuller review of past literature on the subject, will be completed shortly.

Out of the study have come challenges to the conclusions of previous investigators, particularly Thornten Sellin, who have developed evidence used to deny unequivocally the existence of any deterrent or incapacitating effects of capital punishment. This evidence stems by and large from what amounts to informal tests of the sign of the simple correlation between the legal status of the death penalty and the murder rate across states and over time in a few states. Researchers conducting these tests have not considered systematically the actual enforcement of the death penalty, which may be a far more important factor affecting offenders' behavior than the legal status of the penalty. Moreover, generally missing from these studies are other parameters characterizing law-enforcement activities against murder, such as the probability of apprehension and the conditional probability of conviction, which appear to be systematically related to the conditional probability of punishment by execution. In addition, the direction of the causal relationship between the rate of murder in the population and the probability of punishment by execution, as well as the probabilities of apprehension and conviction, is not obvious, since a high murder rate may generate an upward adjustment in the level of these prob-

abilities in accordance with optimal law-enforcement activity. Thus, the sign of the simple correlation between the murder rate and the legal status, or even the effective use of capital punishment, cannot provide convincing evidence for or against the existence of the deterrent effect of capital punishment.

The basic strategy I have attempted to follow has been to develop an economic model of murder and law enforcement against murder, which accounts for major determinants of the murder rate, as well as for the simultaneous relations between murder and law-enforcement activities. I have then derived on the basis of this model a set of specific behavioral implications that can be tested against available data and have tested these implications using simultaneous equation estimation methods. The theoretical analysis yielded sharp predictions concerning the signs and the relative magnitudes of the elasticities of the murder rate with respect to the probability of apprehension and the conditional probabilities of conviction and execution for murder and suggested that the corresponding values of these elasticities can be ranked in a descending order. It suggested also the existence of a systematic relation between employment and earning opportunities and the frequency of murder and other related crimes.

Although in principle the negative deterrent effect of capital punishment may be partly offset, for example, by an added incentive to eliminate witnesses, the results of my empirical investigation are not inconsistent with the hypothesis that, on balance, capital punishment reduces the murder rate. Indeed, the estimated average trade-off between the executions of an offender and the lives of potential victims saved during the period 1933–69, as inferred from the estimated partial elasticity of the murder rate with respect to the conditional probability of execution, is of the order of magnitude of 1 for 8.

Even more significant is the fact that other specific theoretical predictions are consistent with the empirical results. The elasticity of the murder rate with respect to the probability of apprehension is greater in absolute magnitude than its elasticity with respect to a measure of the conditional probability of conviction. The latter elasticity, in turn, exceeds the elasticity

of the murder rate with respect to alternative measures of the conditional probability of punishment by execution. The murder rate is also negatively related to the labor-force participation rate and positively to the rate of unemployment. None of these results is compatible with a hypothesis that offenders do not respond to incentives. Moreover, the results concerning the negative effects on the murder rate of the probabilities of apprehension, conviction, and execution are not consistent with the hypothesis that execution or imprisonment decreases the rate of murder only by incapacitating or preventing convicted offenders from committing further crimes.

These observations do not imply that the empirical investigation has proved the deterrent or preventive effect of capital punishment beyond conventional statistical qualifications. The results may be biased by the absence of data on the severity of alternative punishments for murder and by other data shortcomings. At the same time, it is not obvious whether the net effect of all the shortcomings exaggerates the regression results in favor of the theorized results. The regression results are quite robust to variations in the specific subperiods investigated and are not sensitive to several alternative methods of estimation used in the study. Also, the results of the time-series analysis of variations in the national murder rate are compatible with results from regression analysis of variations in murder rates and other crime rates across states in the United States. In view of this evidence, one cannot reject the hypothesis that law-enforcement activities in general, and executions in particular, do exert a deterrent effect on acts of murder. Strong inferences to the contrary drawn from earlier investigations appear to have been premature.

My investigations into the time trend of crime in the United States include, in addition to the analysis of trends in the frequency of murder, analyses of trends in the frequencies of other crimes against persons and property, of trends in participation in criminal activities of various population groups, and of trends in public and private protection against criminal activities. A specific project that is part of my general investigation is the effect of Supreme Court rulings on the effectiveness of law-enforcement activity by police and courts. Progress toward a first draft of the complete investigation is expected within the current year.

Isaac Ehrlich

The Cost of Access to Legal Remedies

The purpose of this study is to estimate the effects that the costs (in relation to expected returns) of litigation have on the incentive to utilize legal remedies, primarily in civil matters. The theoretical framework applies the expected utility model to decisions involving the initiation of law suits, settling, and going to trial. The study extends my earlier work on the court system. However, the earlier work was mainly concerned with the choice between settling and going to trial, whereas here I focus primarily on incentives to seek legal remedies.

The first source of data to be extensively analyzed are annual records of civil cases filed in New York City from 1936 through 1972 subdivided by type of court (e.g., Supreme Court, Civil Court, Small Claims Court). The allocation of cases among courts is based on the size of the claim filed. The Small Claims Court, which now has a $500 limit, is a particularly rich source of data to test the relevance of economic theory to legal decision making. For this court, annual data are available on the distribution of claims filed and disposed of by size of claims and judgments, respectively; the use of attorneys by plaintiffs and defendants; the methods of disposition (e.g., trial, settled during trial, settled before trial); and the number and dollar amount of successful, partially successful, and unsuccessful judgments awarded to plaintiffs. My preliminary regression estimates tend to support the economic model of litigation. I have found that the demand for seeking legal remedies is positively and significantly related to both the probability of a successful settlement and the unemployment rate (which reduces the time costs of pursuing a legal claim) and is negatively and significantly related to the direct cost of filing claims.

We will also estimate an equation in which the probability of successfully collecting on claims depends in part on the number of claims filed. (The simultaneous nature of the problem results

from the method of using marshals, who are licensed and restricted in number by the City of New York, to collect most judgments. Since the marshals' resources are limited, the greater the number of claims they have to collect, the less the resources devoted per claim and the lower the probability of a successful collection.) The probability of collection is also affected by legal changes, which we will investigate, that now make it more difficult to garnish wages and seize the property of losing defendants. A final part of the analysis of the New York City data involves estimating the effect of the cost of access to the legal system on the distribution of claims. This aspect of the research will be analyzed by examining the response of claims filed to changes in the claim limits set by each court. For instance, the limit in the Small Claims Court has risen from $30 to $500 in the last thirty-five years. Since it is less costly to go through this court in terms of delay and lawyers' fees (a lawyer is not required), one would expect to find that when the limit is raised, for example, from $300 to $500 in one year, there will be a *net* addition to total claims, for the increase in cases in the Small Claims Court will exceed the reduction in cases in the higher court because of the lower costs of litigating in the former than in the latter.

Further empirical analysis will involve examining the demand for legal claims in other jurisdictions, using published judicial statistics. One definite possibility is the federal district court, wherein annual data on civil claims are compiled by the Administrative Office of the U.S. Courts. This study is being conducted jointly with Mr. Samuel Schwarz, a graduate student in economics.

William M. Landes

Legal Theory and Reality:
Some Evidence on Criminal Procedure

It is widely believed that the criminal justice system is breaking down under the strain of an increasing demand for its services and its inadequate resources. Statistics on rising crime rates, recidivism, arbitrary sentencing practices, court delay, and prison riots are cited as evidence that the courts are failing. What has been notably scarcer is systematic empirical research on the criminal court system. The purpose of this study is to begin to remedy this deficiency by applying the quantitative techniques of economics to an analysis of some important issues in criminal court procedure. The data for this study are a random sample of 858 defendants in criminal court in New York City in 1971 containing detailed information of the defendant's prior criminal record and socioeconomic characteristics, the criminal charges against the defendant, the various court proceedings involving the defendant, and the outcome of the case.

The major part of the study contains an empirical analysis of the determinants of pretrial status and the harm issuing from release. Here I first analyze the factors determining the terms on which a defendant may obtain his pretrial liberty and then test whether these factors are also significant predictors of the amount of harm a defendant will do if released on bail. This approach enables me to distinguish between the two dominant hypotheses on the social function of bail. The first asserts that the primary function of a bail system is to ensure the defendant's appearance at trial; the second emphasizes the desirability of using the bail process 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, reduce the likelihood of pretrial liberty) are significant predictors of the likelihood of committing crimes during the period of pretrial liberty but have little predictive power in explaining the high disappearance rate (around 30 per cent) of persons released on bail. This finding, which is the main contribution of the study, provides a powerful rationale (i.e., the prevention of future crimes during the period of pretrial liberty) for the operation of the current bail system—though a rationale that some would argue is inadequate when weighed against the restrictions imposed on the rights of the accused.

The final part of the study focuses on the disposition of cases wherein we examine the determinants of the time elapsed between arrest and disposition or court delay, the determinants of the outcome of plea bargaining, the interaction between delay and outcome, and the role

of pretrial detention in affecting delay and the outcome of cases.

William M. Landes

Economics of Legal Rules

We have completed a paper titled "An Economic Analysis of Legal Rulemaking" *(Journal of Legal Studies,* Vol. III, 1, January 1974, p. 257), which is a continuation of the study of legal procedure and administration reported in last year's *Annual Report.* The present study deals with the choice between rule or standard, or stated differently, between a relatively specific and a relatively general legal command, and with the related question of the allocation of rulemaking responsibilities among different legal institutions such as the courts, legislatures, and administrative agencies. We first present a model of optimum specificity or precision. The model contains a number of implications with respect to reliance on rules vs. standards in various areas of law and with respect to the assignment of rulemaking responsibilities to different kinds of institutions—e.g., it implies greater use of rules in the criminal law, greater use of overly inclusive rules in areas in which transaction costs are low or penalties light, expansion over time in the amount of rulemaking authority delegated by legislatures to administrative agencies, and greater delegation in the American than in the British system of government. These and other implications of the model are compared with, and found to be supported by, casual impressions of the actual operation of the legal process; but no systematic empirical investigation has yet been carried out.

Isaac Ehrlich
Richard A. Posner

Administrative Delay

I have finished collecting data for a study of delay in the administrative process. The study will be in two parts. The first part will be a theoretical discussion of delay in adjudication. The questions to be considered are the costs and benefits associated with changes in the lengths of the various intervals in the disposition of a legal dispute, and the distribution of these costs and benefits among the affected parties (in the context of administrative adjudication, these are primarily various industrial and consumer groups). The second part of the study will be empirical and will have both a descriptive and an analytical component. The descriptive section will present, for the first time, comprehensive statistics on the amount of delay in the different kinds of cases handled by the federal administrative agencies over the period 1955–70. These statistics have been obtained from a variety of sources, principally the annual reports of the agencies and the published opinions in agency decisions. Having indicated the pattern of delay over time and among different kinds of agencies and different kinds of cases, I then hope to take at least the first steps toward (1) explaining the differences, and (2) assessing the productivity of the administrative process in the various areas studied. Data on agency budgets, personnel, and workload, and on the regulated industries, that I have gathered will be used in this analytical effort, but it is too soon to predict the results of the analysis.

Richard A. Posner

The Demand for Private Protection

In 1969, the private sector spent $3.3 billion on security personnel and equipment. What is most striking about this figure is that it is two-thirds the size of the public outlay for protection in that year. Although public expenditures have been investigated, little systematic analysis has been directed toward the private sector's protection expenditures. Since 95 per cent of the private outlays are made by firms, my research explores the determinants of firm demand for private guards. My analysis forcuses on the effects on private protection expenditures of business losses from crime, public protection expenditures, and the availability of insurance.

A firm is assumed to produce two goods: (1) a product that it sells in the market, and (2) self-protection. Both production functions use inputs purchased in the market as well as an entrepreneur's own time. The firm maximizes expected profits with respect to the number of guards it hires, the number of nonguard employees it hires, and the amount of time the entrepreneur

devotes to policing his firm. The firm hires more guards in response to an increase in the endowed loss, an increase in the endowed probability, an increase in the education of guards, and an increase in the importance of the entrepreneur in the output production function. The effects of public expenditures and insurance on the demand for guards must, however, be determined empirically.

The Small Business Administration's 1968 Survey of Crime against Business is used to test the implications of the model. The firm is assumed to estimate its endowed loss and endowed probability by looking at the recent loss experience of firms that are similar to itself in terms of location, industry, and size. If the protection expenditures of these "similar" firms are held constant, the percentage of firms in the group that had a loss during the previous twelve months is a measure of the endowment probability and the mean loss for those firms in the group that had a loss proxies the endowed loss. The crimes included in the construction of the loss figure are burglary, robbery, vandalism, employee theft, and shoplifting.

Maximum likelihood logit estimation is used to determine the effects of the exogenous variables on the probability that the firm hires a guard and on the probability that it subscribes to a protective service (i.e., it "shares" a guard with other firms in its neighborhood). The results show that, even if size of firm and location are held constant, the endowed loss and endowed probability have positive and significant effects on both the probability that the firm hires a guard and the probability that it subscribes to a protective service. An increase in public protection expenditures reduces these probabilities. In addition, firms with insurance are more likely to hire guards or services, thus disputing the moral hazard argument. Interestingly, ghetto firms are not more likely to hire guards than urban nonghetto firms, but they are more likely to subscribe to protective services. This tendency is explained by the fact that ghetto firms are more homogeneous in size than urban nonghetto firms and thus it is easier for them to pool together and share a guard. Further empirical work will consider whether urban firms react differently from nonurban firms; also the firm's ex-

penditures on protective devices will be used as a dependent variable.

<div align="right">Ann P. Bartel</div>

The Sources of Economic Legislation

There are two problems, simultaneous in the literal sense, that must be solved in explaining why economic legislation is passed and takes on its particular content. The first problem is that one should know the precise effects of the legislative policy—not simply that a tariff is protective, but whom it protects, and how much, and at whose cost. The second problem is to explain how the benefited parties are able to obtain passage of the legislation—after all, protective legislation in general involves a deadweight loss to the society in addition to any transfers of income. It is reasonable to assume that the actual beneficiaries of a given legislative policy were its supporters, so knowledge of actual effects of a policy is the easiest source of knowledge of the groups that sought the law.

It is seldom easy to identify and measure the precise effects of a law, but numerous (some by me) attempts at such measurement have been relatively successful. The regulatory policy that I am presently studying is the control over branch banking by states. I seek to answer questions such as: why does Illinois forbid any bank to have a second office whereas California allows essentially unrestricted branching? That the policies differ in effect is easy to show: in 1968 Illinois had one bank office per 10,030 population; California, one office per 6,800 population.

The basic procedure in estimating the effects of the legislation is to calculate the number of banking offices in each of the two states, employing the relationship between bank offices and their determinants (income, area, etc.) of the other state. Then, for example, Cook County would have 671 offices if Illinois had unrestricted branching, instead of the 195 offices it actually had in 1968. If, on the other hand, the Illinois practice were in effect in California, Los Angeles County would have had only 289 offices, instead of the actual 873.

One may translate the effects on bank offices into influence on legislation. In California coun-

ties that would lose a substantial number of bank offices under the Illinois pattern, bankers would benefit from the restriction. In Illinois counties that would gain a considerable number of offices under the California plan, on the other hand, bankers would be injured. In major cities, which have many offices and compete in national markets, restricting the number of offices is injurious to bankers rather than helpful. Given this system of translating economic interest into political representation, we seek to explain differences in legislation. In this particular case, we find that some 14.4 per cent of the state representatives in California in 1960 represented counties in which restrictive branching legislation would be clearly beneficial, and the remaining 85.6 per cent represented counties in which effects would be ambiguous (46.8 per cent) or harmful (38.8 per cent). In Illinois, 34.5 per cent of the state representatives in 1960 were from counties benefiting from restriction, and the remaining 65.5 per cent represented counties in which effects would be ambiguous (28.2 per cent) or harmful (37.2 per cent).

I plan to extend this analysis to numerous other states.

George J. Stigler

Citizen Rights and the Costs of Law Enforcement—The Theory of Controls

I have completed a manuscript on citizen rights and law enforcement that in revised form has been published in the *Journal of Legal Studies,* June 1974. In the paper I argue that the rights of citizens, especially rights to privacy, limit the technology available to the criminal justice system (CJS). The effect of the imposition of these restrictions is to increase the minimum level of criminal activity consistent with a given resource expenditure by the CJS. Thus, a community must choose among triads of citizen rights, crime, and expenditures for repressing crime. Citizen rights and expenditures on crime repression are substitutes for crime repression. My findings indicate that the CJS has tended to substitute reductions in rights for increases in expenditures, and vice-versa, as the relative cost effectiveness of the competing inputs has varied. I include numerous examples to illustrate the point.

The manuscript "Conflicts and Contract: A Theory," which was reported on in last year's *Annual Report,* is being revised and a draft is now available.

Melvin W. Reder

Economics of Health

Introduction

The research program in the economics of health is supported by grants from the Bureau of Health Services Research and Evaluation, U.S. Department of Health, Education, and Welfare, and from the Robert Wood Johnson Foundation. Victor Fuchs and Michael Grossman serve as co-program directors. Mark Pauly of Northwestern University has joined the program as a research fellow for the academic year 1974–75. He plans to work on empirical applications of a model that views the not-for-profit hospital as a physicians' cooperative. Barry Chiswick spent the academic year 1973–74 on leave to the staff of the Council of Economic Advisers. His responsibilities there included health problems and policies.

The program was well represented at the Universities–NBER Conference on the Role of Health Insurance in the Health Services Sector in Rochester in June 1974. Michael Grossman served as a member of the conference planning committee and the chairman of a session on national health insurance. Barry Chiswick and Victor Fuchs served as discussants of papers presented at this session.

The studies that are reported below focus on the production and demand for health at various stages in the life cycle and on the cost of medical care. Our emphasis on the determinants of health is reflected by Eugene Lewit's work on prenatal medical care, birth outcome, and infant health, and by Michael Grossman's work on the relationship between schooling and adult health. During the past year, Grossman has begun a new study on the demand for preadolescent and adolescent health that will complement the health models that we have constructed for other stages in the life cycle.

Our emphasis on the cost of medical care as determined by the interaction between supply and demand is reflected by Edward Hughes'

work on the utilization of surgical manpower, Barry Chiswick's work on hospital and nursing home utilization, Marcia Kramer's work on the demand for abortion in New York City, and Melvin Reder's work on medical malpractice insurance. During the past year, Victor Fuchs has begun to investigate the earnings and hours of work of paramedical personnel. Using data from the 1960 and 1970 censuses of population, he will study variations in quality-adjusted hourly earnings both over time and among geographic regions of the United States. In addition, he will estimate various parameters of the supply and demand functions for paramedical personnel.

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

Barry R. Chiswick, "Comment: The Effect of Health Insurance on the Price and Quantity of Medical Care," by Martin S. Feldstein and Bernard Friedman, Universities–NBER Conference on the Role of Health Insurance in the Health Services Sector, June 1974.

Victor R. Fuchs, "Comment: Improvements in Health Status Attributable to Medicare and Medicaid," by Bernard Friedman, Universities–NBER Conference on the Role of Health Insurance in the Health Services Sector, June 1974.

————————, "Why Health Economics?" The Mount Sinai Journal of Medicine, 60, No. 4, July–August 1973.

Michael Grossman, "The Correlation between Health and Schooling," NBER Working Paper No. 22, December 1973.

Edward F. X. Hughes, "The Demand for Surgical Residents: Some Preliminary Observations," Surgery, in press.

————————, "Halsted and American Surgery," Surgery, 75, No. 2, February 1974.

Edward F. X. Hughes, Eugene M. Lewit, and Elizabeth H. Rand, "Operative Work Loads in One Hospital's General Surgical Residency Program," The New England Journal of Medicine, 289, No. 13, September 27, 1973.

Edward F. X. Hughes, Eugene M. Lewit, Richard N. Watkins, and Richard Hanschin, "Utilization of Surgical Manpower in a Prepaid Group Practice," NBER Working Paper No. 19, December 1973.

Michael Grossman

Production and Demand for Health at Various Stages in the Life Cycle

In the course of earlier work, I constructed and estimated a model of the demand for "good health" by adults. (See The Demand for Health: A Theoretical and Empirical Investigation, New York: National Bureau of Economic Research, 1972.) A fundamental proposition of my model is that what consumers demand when they purchase medical services are not these services per se but rather good health. Based on this proposition, one should derive the demand curve for medical care from the interaction between the production function of health and the demand curve for health. I have used this approach to model and test the notion that an increase in years of formal schooling completed should cause health to rise. Specifically, the efficiency with which individuals transform medical care and other inputs into better health might rise with schooling. This would tend to create a positive correlation between schooling and the quantity of health demanded.

During the past year, I completed a study in which I develop a methodological framework that can be used to introduce and discuss several alternative explanations of the positive correlation between years of formal schooling completed and adults' health. I also test these explanations empirically in order to select the most relevant ones and to obtain quantitative estimates of different effects. This study, "The Correlation between Health and Schooling," will be published in Household Production and Consumption, ed. Nestor E. Terleckyj, NBER Studies in Income and Wealth, Volume 40. Within the context of the household production function approach to consumer behavior there are com- -pelling reasons for treating both schooling and health as endogenous variables. It is reasonable to assume that healthier students are more efficient producers of additions to the stock of knowledge or human capital via formal schooling. If so, they would increase the quantity of investment in knowledge they demand as well as the number of years they attend school.

In the theoretical section of the study, I formulate a recursive system whose principal equations are demand curves for children's health,

adults' health, and college education. I then show how this system generates causal relationships from schooling to health and from health to schooling. In addition, this system generates relationships from "third variables," such as parents' schooling and physical and mental ability, to both health and schooling. In my theoretical analysis I stress that current and past health should be positively correlated and that healthier students should have an incentive to attend school for longer periods of time. Therefore, the coefficient of schooling in a regression with current health as the dependent variable would be biased upward if past health were not included in the regression. Similarly, the schooling coefficient would be biased if relevant third variables were omitted from the health function.

The empirical work in the study is based on data contained in the NBER–TH sample. Candidates were given seventeen specific tests that measured five basic types of ability: general intelligence, numerical ability, visual perception, psychomotor control, and mechanical ability in 1943. In 1955, Robert L. Thorndike and Elizabeth Hagan collected information on earnings, schooling, and occupation for a civilian sample of 9,700 of these 75,000 men. In 1969, the NBER mailed a questionnaire to the members of the Thorndike–Hagan sample and received 5,085 responses.

In the main empirical section of the study, I estimate a recursive health-schooling model by ordinary least squares. In this model, the index of current health is a man's self-rating of his health status in 1969 as excellent, good, fair, or poor. I also examine the mortality experience of the Thorndike sample between 1955 and 1969.

The major empirical results are as follows. With past health and third variables held constant, schooling has a positive and statistically significant effect on current health. This evidence favors a causal relationship that runs from schooling to current health. Other variables included in the analysis are the hourly wage rate, nonearnings income, wives' schooling, absolute value of the difference between actual weight and ideal weight for a given height, job satisfaction, parents' schooling, and physical and mental ability measures from the 1943 test scores. These results are not altered when the

health function is estimated by methods other than ordinary least squares. The mortality experience of the Thorndike sample between 1955 and 1969 confirms the important role of schooling in the health function.

In my theoretical analysis of relationships between schooling and adults' health, I stress that health at early stages in the life cycle should be a determinant of formal schooling completed and a determinant of health at later stages in the life cycle. In future research, I plan to study variations in children's health in a systematic fashion. This research should increase our knowledge about the relative effectiveness of alternative policies designed to raise schooling and health levels. The research will build on the important distinction between quantity and quality that is stressed in much of the literature on the economics of fertility and optimum family size.

The production function of children's health should depend on genetic endowment, various types of medical services, and environmental factors that are shaped to a large extent by parents. In particular, it is plausible that an increase in parents' schooling makes the production of healthy children more efficient. From my analysis I should be able to answer questions such as: With genetic endowment held constant, what is the size of the effect of children's medical care on health? What are the relative contributions of parents' schooling, medical care, and other variables to the health of children? How sensitive are the quantities of health and medical care demanded to income, the price of care, and the opportunity cost of parents' time?

I plan to estimate production and demand functions with several data sets. These include the 1963 and 1970 health surveys conducted by the National Opinion Research Center and the Center for Health Administration Studies of the University of Chicago, one or more years of the U.S. Health Interview Survey, and cycles two and three of the U.S. Health Examination Survey. The last data set is particularly valuable because it contains measures of health from detailed physical examinations of a cohort at ages 8 and 14, measures of intelligence quotient (Wechsler Intelligence Test) at these two ages, and retrospective information on children's health at birth and medical history. With this sample, one can

assess whether various components of child quality are substitutes or complements by analyzing the relationship between health and intelligence.

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

Utilization of Surgical Manpower

In the initial study of the surgical manpower project, the operative workloads of a population of nineteen general surgeons in fee-for-service community practice had a mean weekly value of 4.3 hernia equivalents (HE) and a median value of 3.1 HE.[1] These values were well below a consensus standard of a full workload of 10 HE suggested by a number of surgeons from a variety of practice settings. Accordingly, a conclusion was drawn that there was an underutilization of valuable surgical skills in this population of general surgeons. This conclusion was supported by a time-motion study that revealed working weeks in the range of forty hours (including emergency and night work).

The question still remained, however, to what extent the 10 HE standard was in fact a reasonable one. To investigate this question and the influence of a prepaid setting on a surgeon's workload, we measured the surgical workloads of a population of seven general surgeons in a prepaid group practice with 158,000 enrollees. The surgeons were all graduates of American medical schools and board certified. In addition, two of the surgeons were certified by the Board of Thoracic Surgery. The surgeons performed all the general surgery within the prepaid group, with the exception of plastic and open-heart surgery, which were referred out. It was the opinion of the surgeons that very little surgery was performed on subscribers outside the group other than this surgery that was specifically referred out. The prepaid plan owned its own hospital and the surgeons performed no surgery at other institutions. The surgeons were compensated on the basis of their seniority in the group, their training, and their past experience, rather than on the basis of their workloads.

All operations performed by the seven sur-

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

geons in the operating room of the prepaid group practice hospital for a six-month period were recorded and seasonally adjusted for a forty-eight-week working year. These operations were performed on both hospitalized and ambulatory patients. In the six-month period, the seven surgeons performed 1,523 operations, with 377 secondary procedures. Of these procedures, 1,163 (76 per cent) were performed on inpatients and 360 (24 per cent) on ambulatory patients.

The weekly operative workloads for the surgeons ranged from 6.8 HE to 10.5 HE (see Table II-3). The mean weekly workload was 9.2 HE and the median, 9.9 HE. Thus the workloads of this population of surgeons approximated the consensus standard of 10 HE. In fact, four of the seven were at or above this standard. Inpatient surgery represented the bulk of the work of the surgeons. The median complexity of the inpatient procedures by surgeons was 1.27 HE and the median complexity of ambulatory cases per surgeon was 0.23 HE. The median complexity of all operations was 1.00 HE, not substantially different from the median value found in the community practice previously studied (0.95 HE). There was evidence of specialization within the population of surgeons in that fourteen of the seventeen cases more complex than 4 HE (thoracic and abdominal vascular surgery) were performed by the two surgeons with thoracic certification. This was in sharp contrast to the community practice, where the small number of complex cases performed in the year of the study were scattered almost at random among the surgeons, regardless of their certification status. Further support for specialization within the population was found in the fact that there was a negative correlation ($r = -0.5$) between the volume of the inpatient and the ambulatory workload of each surgeon. Workloads were not related to the age of the surgeons or to the duration of their affiliation.

Some of the difference in the mean weekly volume of surgery between the prepaid group and the community practice setting can be accounted for by the age distribution of surgeons in the community practice. There, nine of the nineteen surgeons were older than 56 years, the age of the oldest surgeon in the prepaid

TABLE II-3

Volume and Complexity of Inpatient, Ambulatory, and Total Operative
Workloads of Seven General Surgeons in a Prepaid Group Practice

Surgeon	No. of Inpatient Operations Per Week	No. of Ambulatory Operations Per Week	Inpatient HE Per Week	Ambulatory HE Per Week	Total HE Per Week	Mean HE Per Inpatient Operation	Mean HE Per Ambulatory Operation	Mean HE Per All Operations
A	6.0	1.7	10.1	.38	10.5	1.68	.23	1.37
B	7.4	.9	10.0	.29	10.3	1.36	.31	1.24
C	8.3	2.0	9.7	.49	10.2	1.17	.25	.99
D	6.5	3.5	8.9	1.04	9.9	1.36	.30	.99
E	8.1	2.2	9.0	.41	9.4	1.11	.19	.91
F	7.2	2.3	6.9	.61	7.5	.96	.27	.80
G	4.8	2.6	6.1	.78	6.9	1.27	.30	.93
Mean	6.9	2.2	8.7	.57	9.2	1.27	.26	1.03
Median	7.2	2.2	9.0	.49	9.9	1.27	.27	.99

group. The ten other surgeons in the community had a median weekly workload of 5.3 HE, which is 30 per cent closer to the median value in the prepaid group practice but still substantially less. The most salient determinant of the difference in the size of the workload per surgeon in the two settings would appear to be the difference in general-surgeon-to-population ratios. The general-surgeon-to-population ratio in the group was 4.4 per 100,000, a low ratio compared to other prepaid group practices, and to the U.S. in general. The general-surgeon-to-population ratio in the previously studied community practice was 10.1 per 100,000, roughly comparable to that of the U.S. as a whole, at the time of the study. Were the fee-for-service community to have the same general-surgeon-to-population ratio as the prepaid group and the same number of operations were to be performed there as in the previous study, the mean HE per week of surgeons would rise to 9.9 HE, approximating that in the prepaid group.

Just prior to the study, the number of subscribers in the plan had increased substantially. It would be interesting to know where the prepaid group practice stood at the time of the study in relationship to the equilibrium between the supply of general surgeons and the demand for surgery from the subscribers of the plan. Valuable information might be obtained from longitudinal studies of the volume and the complexity

of surgery performed in relationship to the surgeon-to-population ratio of this particular prepaid group. It is worth pointing out that shortly after this particular study was performed, an additional surgeon was added, suggesting that the consensus standard of 10 HE per week may in this setting approach a maximum for a desirable workload.

An examination of the frequency distribution of operations by complexity in the two settings suggested some similarities. In fact, in each setting, the five most common procedures were exactly the same. These findings would tend to raise the question whether a diminished rate of surgical procedures, a phenomenon associated with prepaid group practice, exists in the population receiving care from the seven general surgeons. Studies on the incidence of specific operations in the prepaid group practice are now underway to determine the extent to which operative rates may differ from fee-for-service settings. The utilization of the ambulatory modality for 24 per cent of all general surgical cases in this prepaid group practice would appear to be an additional economy in the delivery of surgical services in the prepaid group practice.

A study of the time utilization of these seven general surgeons is now in progress and suggests substantially longer working weeks in the prepaid group than in the community practice group. Studies are also underway on the utiliza-

tion of operating room technicians in this particular prepaid group practice. Richard Watkins, M.D., of the Department of Community Medicine, Mount Sinai School of Medicine, is a collaborator on the group-practice studies.

With the assistance of John N. Palumbo, M.D., formerly a fourth-year medical student at Mount Sinai School of Medicine, a cataract equivalent similar to the HE was developed for the specialty of ophthalmology and a workloads study performed on a population of ophthalmologists in community practice.

As in past years, Eugene Lewit has acted as a collaborator on all studies, and we have received able research assistance from John Wolfe.

Edward F. X. Hughes

Hospital and Nursing Home Utilization

My NBER Working Paper No. 2, "Hospital Utilization: An Analysis of SMSA Differences in Occupancy Rates, Admission Rates and Bed Rates" (June 1973) has been reviewed by the NBER staff reading committee and is now being revised.

The theoretical analysis assumes that in the short run the number of short-term general hospital beds per thousand population (bed rate) is fixed, and the admission rate and occupancy rate are determined simultaneously. Beds are viewed as endogenous in the long run, and the bed rate and the admission rate are determined simultaneously. The empirical analysis is performed for a sample of 192 SMSA's using 1967 data on hospital utilization.

A model for the randomness of hospital admissions hypothesizes that occupancy rates are higher the larger the population, the higher the (predicted) admission rate, and the smaller the number of hospitals, ceteris paribus. These hypotheses are confirmed by the data. In addition, occupancy rates are found to be higher in SMSA's with fewer beds per capita, where a greater fraction of the population is nonwhite, and where winter climates are colder. Since the admission rate and the bed rate are held constant, the racial and climatic variables influence the occupancy rate through their effect on length of stay.

The analysis of SMSA differences in admission rates indicates a strong significant negative effect of the (predicted) occupancy rate. SMSA's in which hospitals are more crowded (higher OR) ration admissions more strictly, and consequently have a low admission rate. With occupancy rates held constant, a higher bed rate implies a greater number of vacant beds per capita and therefore a lower probability that an admission will delay the admission of a more serious case. When the bed rate is treated as an endogenous variable, the elasticity of admissions with respect to (predicted) beds is 0.4. Admission rates are found to be higher the greater the extent of insurance coverage, the greater the number of surgeons per capita, the colder the winter climate, the larger the nonwhite fraction of the population, and the lower the median family income. The number of nonsurgical MD's per capita appears to be unrelated to the SMSA differences in the admission rate.

The analysis of SMSA differences in bed rates indicates that (predicted) admissions, emergencies, and the proportion of the SMSA beds in federal hospitals all have positive and highly significant effects. The elasticity of beds with respect to admissions is 0.9. The statistical significance of the federal bed variable indicates less than perfect substitution of federal hospital beds for other beds, possibly because patients must be veterans to occupy federal beds. There is a weak positive income elasticity of demand for beds. The bed rate is uncorrelated with the rate of population growth, suggesting hospital bed construction "keeps up" with population growth. This is consistent with the insignificant effect of population growth on occupancy rates.

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, demographic, and health variables. The hypotheses developed in the theoretical analysis are, in general, confirmed.

Preliminary work on analyzing SMSA differences in the utilization of nursing homes by the aged in 1967 has proved fruitful. The data indicate a higher use rate the larger the fraction of the aged who are female, the greater the level of income, and the greater the proportion of mar-

ried women who are in the labor force. The expected age patterns also emerge from the data. These findings are consistent with the hypothesis that nursing homes are imperfect substitutes for out-of-nursing-home care for the aged. The price of nursing home services is found to be sensitive to the wages of factors of production used in the provision of this care. I plan further research on this topic.

Barry R. Chiswick

Abortion and Fertility in New York City

Concurrent with its legalization, induced abortion has emerged as a widely practiced method of fertility control. The objectives of my study are (1) to identify factors associated with the demand for legal abortion, (2) to assess the impact of legalization on fertility, and (3) to determine the role played by abortion in present-day fertility control efforts. I have developed a theoretical model of abortion demand within the general framework provided by the new economic theory of fertility. Parameters of the model are now being estimated with cross-sectional and time-series data for New York City residents who, since July 1970, have had ready access to legal abortion.

Vital records from the New York City Department of Health, Fourth Count Summary Statistics from the Census, and information on religious affiliation from the Population Health Survey have been used to obtain demographic and socioeconomic variables, by race, for 296 intracity areas. During the year beginning September 1, 1970, the total legal abortion rate (LEGAB) of these areas averaged 1.22, as compared to a mean total fertility rate (TFR) of 2.41 during the last year in which no births could have been averted through legal abortion (October 1969–September 1970). Both LEGAB and TFR are cumulations of age-specific rates and hence may be interpreted as measures of lifetime outcomes per woman. LEGAB is significantly higher for blacks (1.81) than for whites (0.95), and among whites it is greater in areas of high (over 40 per cent) than of low (under 5 per cent) Puerto Rican concentration (1.38 versus 0.71). These racial differences in the demand for abortion are not accounted for by differences in socioeconomic status. On the contrary, within income or education classes they are amplified —e.g., LEGAB averages 2.64 for blacks and 0.62 for non-Puerto Rican whites when 1969 per capita income is in the $3,500–$4,499 range.

Univariate analyses show that, among both blacks and non-Puerto Rican whites, abortion demand increases markedly with income. These increases are particularly impressive in view of the fact that sliding fee scales at municipal hospitals and Medicaid both lower, often to zero, the price that the poor pay for abortions. It seems most improbable that middle- and upper-income women use less effective contraception. However, they may well be running the risk of unwanted pregnancies for a greater portion of their lives (this would be the case if they desired fewer children); it also appears likely that they have a higher propensity to abort those unwanted pregnancies that do occur, despite the higher price of abortion. Somewhat surprisingly, religious affiliation does not appear to be an important determinant of the demand for abortion. Also, only for whites does the abortion rate show a strong inverse association with the percentage married; for blacks, marital status is of little relevance.

Analysis of citywide data indicates that the legalization of abortion produced a decline of 9.4 per cent in births per thousand New York City women between October 1969–September 1970 and April 1971–March 1972. This was determined by comparing changes in fertility rates and legal abortion rates in New York City vis-à-vis the rest of the country over this period. An additional 5.8 per cent decline in fertility over the eighteen months, both locally and nationwide, is attributable to factors other than the law. I will investigate the manner in which fertility differentials across areas have been altered once the requisite data are available. I predict that the decline in fertility will be greatest among the poor, both because their prior level of unwanted fertility is hypothesized to have been greater, and because they experienced a greater reduction in the price of abortion.

The mean conceptive delay (interval from last delivery to current conception) of previously pregnant New York City women receiving legal abortions is 3.3 years, or 43.5 lunar months. In contrast, mean conceptive delays among sexu-

ally active, fecundable women practicing no contraception are known to be on the order of about five months. From this we may infer that legal abortion is generally employed, by those who resort to it at all, as a back-up to fairly effective contraception, rather than as a substitute for all preconceptive fertility control.

Further evidence corroborating this impression of the secondary role assigned to abortion in fertility control strategies comes from an analysis of data on repeat legal abortions. I propose a model wherein the rate at which repeats (R) are generated by the total aborting population depends on two variables: the monthly probability of conception following the resumption of ovulation (p), and the monthly rate at which women leave the pool of potential repeaters (r). The precise form of this relationship is specified, and its biological parameters are evaluated. A curve then fitted to monthly data on R through June of 1972 shows these to be most consistent with $p = 0.005$ and $r = 0.03$. Since fecundability (p) is on the order of 0.15 when no conception control is practiced, conception control following abortion is approximately 97 per cent effective, which is to say quite good, though not without room for improvement ($p \approx 0.001$ with the pill).

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

Experience and the Demand for Healthy Infants

The purpose of this study is to analyze the effect of the demand for children, pregnancy experience, and prenatal care on individual pregnancy outcomes and hence aggregate pregnancy loss rates. I am using the household production model of demand theory to study the demand for and production of healthy infants. The demand for healthy infants is viewed as resulting from a household demand for children, with infant health being the primary component of child quality produced during pregnancy and early infancy. In addition to being a component of child quality, variations in infant and fetal health will influence survivorship per se and hence will be an important determinant of the number of children in a household at any given time.

Pregnancy itself is viewed as a biological pro-

duction process wherein inputs of market goods, such as medical care, and household time are combined within the mother's body to produce a child. Both parents and physician may be quite uncertain about the value of these inputs when combined with the mother's own biologically determined reproductive efficiency (her ability to produce children of given quality at a given cost). A primary means of determining a mother's reproductive efficiency, hence the cost of a successful pregnancy to her, and perhaps the productive value of the goods and time inputs, is through repeated pregnancies. Thus, one would expect past experience with pregnancy, both good and bad (or lack of past experience) to affect behavior during a current pregnancy and to be an important factor in the decision to attempt subsequent pregnancies.

A simple theoretical model that I have developed suggests that the effect on the demand for children (and hence, on pregnancies) of variation in individual biological efficiency will very much depend on the price elasticity of the demand for children. The most important prediction derived from this model is that for "reasonable" values of the price elasticity, a decline in biological efficiency will lessen the demand for surviving children (since they are more costly) but increase the demand for pregnancies since more pregnancies are required per survivor. This implies that in measuring prenatal death rates for large population groups, such as nations or states, those members of the population whose reproductive efficiency is low will be more heavily represented because of their repeated, perhaps unsuccessful, pregnancies. An interesting finding along these lines is that the more heterogeneous the distribution of biological efficiency in a population group (mean efficiency being assumed constant), the higher will be the measured mortality rates. It is my intention to investigate this hypothesis by measuring the effect of differences in the distribution of education of females of child-bearing age (a correlate of reproductive efficiency) on infant mortality rates across SMSA's in the U.S. for rates centered on 1960. I will attempt an additional test using data on differences in the distribution of pregnancy experience among health districts in New York City for 1970.

In addition to influencing the decision to attempt additional pregnancies, the sequential nature of the child-bearing process allows a household to learn about its own biological production function. I intend to estimate demand and production equations for pregnancy outcomes using data about the 1970 New York City birth cohort (including pregnancies that ended in both live births and stillbirths). Here, functions relating not only to outcomes, such as birth weight or prenatal mortality, but also to the demand for and effect of prenatal care will be estimated from information available on parents' socioeconomic characteristics, pregnancy history, and care utilization during the 1970 pregnancy.

To date, I have investigated two parameters of the demand for prenatal care during pregnancy—the interval between the woman's last menstrual period and her first prenatal visit and the number of prenatal visits. These variables are important because obstetricians believe that early, regular prenatal care is important in determining the success of a pregnancy. Results from these multiple regression equations suggest that an increase in the number of live children in the home is associated, ceteris paribus, with later care and fewer visits, whereas negative pregnancy experiences and fetal or infant deaths lead to earlier, more intensive care. Interestingly, only husband's education, a proxy for permanent income, is significantly associated with earlier care, whereas both husband's and wife's education are equally important in determining the number of visits. Additional attempts will be made to test for possible interaction effects as well as to measure the importance of these exogenous household variables and the amount of care received by a prospective mother in determining the final pregnancy outcome.

I expect that this research will lead to a better understanding of the individual decision-making process underlying aggregate prenatal and infant mortality rates. This knowledge should improve the perspective from which to interpret differences in rates among nations and smaller population groups as well as changes in these rates over time.

Eugene M. Lewit

Medical Malpractice

I expect to complete a first draft of a paper on medical malpractice by the end of winter 1974. This paper uses the report and appendices of the President's Commission on Medical Malpractice as a basis for discussing the role of malpractice in (1) explaining the rise in the cost of care during the 1960s, and (2) altering the nature and costs of patient-physician transactions in providing medical care. This discussion is then used as a basis to assess the present (tort) system of allocating the costs of malpractice as between physicians and patients relative to possible alternatives such as "no fault."

Melvin Reder

Health Manpower

I am beginning a new study of health manpower with primary emphasis on workers with no more than seventeen years of schooling, the so-called paraprofessional and support personnel. I shall use the 1/100 samples of the 1960 and 1970 censuses of population to estimate earnings and hours of work in 1959 and 1969 of health workers classified by sex, color, schooling, age, occupation, geographic location, and other variables. Levels and rates of change of earnings will be analyzed with models that incorporate medical insurance, unionization, and other variables affecting demand and supply. The effects of licensure and other institutional factors on earnings and the effects of wage differences on manpower utilization will also be explored.

Victor R. Fuchs

Population and Family Economics

Introduction

During the past year, this research program continued to emphasize the economic determinants of marriage, fertility, and contraception and to explore such related aspects of family behavior as home investments in children, trends in female labor supply, male-female differences in specific human capital investment, and the life-cycle distribution of family income. The program is directed by Robert Willis and receives support

from the Ford Foundation and from the Center for Population Research, National Institute of Child Health and Human Development, Department of Health, Education and Welfare.

A major part of fertility research this year has been devoted to the theoretical and empirical investigation of the demand for contraception and the impact of imperfect fertility control on the demand for children. Reports that follow by Robert Michael and Robert Willis and by James Heckman and Robert Willis describe this research in greater detail. A complementary study of the demand for abortion by Marcia Kramer is described in the staff reports on the Economics of Health. Another important dimension of fertility research has been the investigation of the timing and spacing of births over the reproductive life cycle of individuals. An empirical investigation in this area was completed by Sue G. Ross, and some theoretical and statistical methods for studying life-cycle fertility and contraception are developed in papers by James Heckman and Robert Willis. The aggregate concept that corresponds to the timing and spacing of births over the life cycle of individuals are age- and parity-specific cohort birth probabilities. Warren Sanderson has completed several sections of his study of trends in U.S. birth probabilities and has attempted to adapt microeconomic theories of fertility so that they may be applied to variation in these probabilities through time.

Gary Becker has completed two papers on the theory of marriage and a paper on social interactions that applies the concept of interdependent preferences to a wide variety of social phenomena, including intrafamily relations. Becker, Elisabeth Landes and Robert Michael are beginning empirical investigations of marital instability using the framework provided by the economic theory of marriage which are described in the report by Becker and Landes in this section and the report by Michael in the Education and Information section of Chapter 3.

In research on related aspects of family behavior, Arleen Leibowitz has completed papers that examine the effects of child-bearing on women's allocation of time within the home and the effects of time spent with young children, parental education, and family income on the subsequent schooling and adult income achieved by these children. Elisabeth Landes has completed a study of the effects of specific investments in human capital on male-female differences in wages and employment in which she finds that higher turnover rates of females caused by their family obligations leads firms to be less willing to invest in women than in men. Her work suggests, however, that continued growth in female labor-force participation will facilitate specific investment resulting in firmer career attachments by women and, quite likely, readjustments in fertility behavior and child-care arrangements. James Smith and Robert Willis have begun a study of time trends in life-cycle labor supply by married women that will attempt to explain the remarkable growth in female participation rates over time. Smith is also applying his life-cycle model of family behavior to an empirical study of the distribution of family earnings. Michael Boskin has joined the population studies program and will investigate public finance aspects of demographic behavior.

The second of two population conferences sponsored by the NBER and the Population Council has been published in the March–April 1974 *Supplement* of the *Journal of Political Economy*. Plans have been made to publish the papers from the two conferences, along with "A Theory of Marriage: Part I" by Gary Becker, in a single volume tentatively titled *Economics of the Family: Marriage, Children, and Human Capital*. This volume will be edited by T. W. Schultz, who also edited the *JPE Supplements* of March–April 1973 and 1974. The contents of these conferences were described in last year's *Annual Report*. The population program was also represented at the November 1973 NBER Conference on Research in Income and Wealth by James Heckman, Robert Michael, and Robert Willis, whose papers will appear in the forthcoming NBER Income and Wealth Conference volume *Household Production and Consumption*, edited by Nestor E. Terleckyj.

Papers that were published last year or are in press or are available in preliminary form are mentioned in the individual reports that follow.

Robert J. Willis

The Economics of Fertility Control

As we indicated in last year's *Annual Report,* we have begun a joint study of how the costs of fertility control affect fertility behavior. Most economic analyses of fertility behavior assume that fertility control is costless and focus on factors that influence desired fertility. We have instead introduced into the usual static fertility demand framework a fertility control cost function that permits us to analyze how changes in the costs of fecundity, contraception, and abortion influence actual fertility. We have completed one paper on this project to date, "Contraception and Fertility: Household Production Under Uncertainty." The paper was presented in November 1973 at an NBER Conference on Research in Income and Wealth, and is forthcoming in an NBER conference volume, *Household Production and Consumption.* The paper is currently available as NBER Working Paper No. 21.

In that paper we emphasize that couples are very uncertain about the number of children who will be born to them and argue that this uncertainty affects family decisions about money and time investments in first-born children, as well as decisions about the composition and timing of consumption, savings, and time-allocation behavior. In our formal model we assume that actual fertility is a stochastic variable resulting from a Markov renewal process. The family selects an optimal level of contraception—which affects the probability distribution of fertility outcomes—wherein the usual economic conditions for optimality obtain. The benefits from improved levels of contraception are identified as a reduction in the expected number of unwanted children and a reduction in the variance or uncertainty about the number of children a family will have. We emphasize that the costs of improved contraception may include forgone time, sexual pleasure, religious principles, and health, as well as money expenditures.

We have used the 1965 National Fertility Survey data to study (1) the determinants of adoption of the oral contraceptive in the United States from 1960 through 1965; and (2) the relationship between a couple's specific contraceptive technique and its actual fertility outcome. We expressed the probability of adoption of the pill within specific birth intervals as a logistic function of such factors as wife's age, wife's education, family income, prior contraceptive use, and prior contraceptive failure. Estimating this logistic function by a maximum likelihood method, we obtained rather strong support for our hypotheses about the nature of the fertility control cost function. We also found that couples who had used relatively efficient contraceptive methods during early intervals between births experienced somewhat lower average fertility, apparently less "unwanted" fertility, and appreciably lower variance in their fertility.

We plan to pursue this project in terms of both the determinants of adoption of specific contraceptive techniques and the relationship between technique adoption and fertility outcomes. On the former topic we intend to study the time-series pattern of adoption of the pill during the 1960s and the differential rates of use of several specific techniques through the 1950s and 1960s, using the 1955, 1960, 1965, and possibly the 1970 fertility surveys. On the latter topic, we hope to document further the relationship between a couple's contraceptive behavior and the uncertainty it faces in terms of dispersion in its expected fertility.

Robert T. Michael
Robert J. Willis

Toward Broadening Economic Models of Fertility

The development of the economic theory of fertility over the last two decades was in large measure a response to a need to understand the dramatic variations in fertility that have been occurring in the United States. In the past year, building on previous work on fertility done at the NBER, I have created a new economic model of fertility that, hopefully, will aid our understanding of these phenomena. The model is similar in structure to the Willis[1] model of fertility except that, rather than dealing with a single household, it deals with a large number of households. The new model has several intriguing features. First, it does not assume that each household maxi-

[1] Robert J. Willis, "A New Approach to the Economic Theory of Fertility Behavior," *Journal of Political Economy,* Vol. 81, No. 2, Part II (March–April 1973), pp. S14–S64.

mizes a utility function, although it is consistent with that approach. Thus, the model shows that it is possible to develop an *economic* theory of fertility that does not necessarily assume rationality (in the sense of consistent preferences) on the part of a household. Another intriguing aspect of the model is that its implications are in terms of fertility averages rather than in terms of the fertility of a single household. The model also potentially has implications for changes in the parity (birth order) distribution of births with changes in economic conditions. Work on formalizing these implications is scheduled for the future. A more complete discussion of the model discussed above can be found in NBER Working Paper No. 36.

In addition to work on the economic theory of fertility, my work on developing and analyzing age- and parity (birth order)-specific birth probabilities continues. The birth probability series were developed in order to ascertain the details underlying time-series fertility movements in the United States. These series show some rather surprising patterns both with respect to the timing of fertility movements and their variations between age and parity groups. Age- and parity-specific birth probabilities for cohorts of native white women born in the twentieth century and a brief analysis of them are presented in NBER Working Paper No. 23.

Warren C. Sanderson

Stochastic Models of Reproduction

Biological considerations make it natural to consider human reproduction as a stochastic process in which the number and timing of births and traits of children (e.g., sex, intelligence, health, etc.) are uncertain and not subject to direct control. These considerations imply that family fertility decisions are inherently sequential and are made under conditions of uncertainty. The goal of this project is to develop an integrated theoretical and econometric model of fertility behavior within a sequential stochastic framework.

Some initial findings from this project are reported in a paper, "Estimation of a Stochastic Model of Reproduction: An Econometric Approach." This paper was presented in November 1973 at an NBER conference on Research in Income and Wealth and is forthcoming in the NBER Conference volume, Nestor E. Terleckyj, ed., *Household Production and Consumption.* The paper is currently available as NBER Working Paper No. 34. A shorter exposition of our statistical model and empirical findings is contained in the paper "Stochastic Choice and Fertility Outcomes," which was presented in New York at the American Statistical Association Meeting in December 1973. This paper is forthcoming in the *Proceedings of the American Statistical Association.* We presented some further results of our research to the NSF–NBER Conference on Decision Rules and Uncertainty in Berkeley, March 1974.

Our research is proceeding along three interrelated fronts. First, we are attempting to construct an economic theory of fertility behavior that explicitly takes into account both the sequential and uncertain nature of family fertility decisions. At the beginning of any month (e.g., from the beginning of marriage to menopause excluding periods of temporary sterility owing to pregnancy) a couple determines its probability of conception during that month by deciding whether or not to contracept and, if so, how efficiently. This decision is assumed to reflect expected utility maximizing choices in which the current costs of contraception are balanced against the utility associated with each possible future fertility outcome weighted by the probability of that outcome. The time path of contraception decisions depends on the stochastic realizations of the reproductive process and on the time paths of income and the opportunity cost of children. For example, we show that a rising life-cycle income profile is likely to result in a sequence of decisions designed to space births, whereas a rising time path of child costs will impel a couple to have as many children as it wishes to as quickly as possible. In the latter case, the longer it takes a couple to have, say, the second child, the less likely it is to wish to have a third child. As another example, we show that if optimal contraception is sufficiently imperfect (i.e., the chance of contraceptive failure is high), a couple may begin contracepting sooner than it otherwise would in order to reduce the chance of future "excess" fertility.

The second part of our project involves the formulation of an appropriate econometric methodology for estimating the effect of economic and demographic variables on contraception decisions and fertility realizations within the stochastic framework suggested by our theory. A number of new statistical problems arise in such a framework. Among these, we have concentrated on the problem of heterogeneous populations in the two papers cited above. This problem is the result of unobserved persistent variations in the monthly probability of conception across women in a sample, variations caused by unmeasured differences in fecundity, frequency of intercourse, or efficiency of contraception, which, in turn, are related to omitted economic variables and family characteristics that determine health, the cost of contraception, and the demand for children. If heterogeneity is ignored, estimates of the parameters of exogenous variables will be biased (even if the persistent unobserved components are uncorrelated with these variables) because of a selection mechanism that confounds changes in behavior—the relationship we seek —with changes in the composition of the sample over time caused by unmeasured differentials in the probability of conception. We present an econometric method that enables us to estimate the fraction of persistent variance in total variance at the same time that we obtain unbiased estimates of the parameters of exogenous economic and demographic variables.

The statistical model we presented in the papers cited earlier is too simple to be of practical use in testing our theory of fertility behavior. That theory implies that the probability of conception and contraception decisions are determined jointly. Recently, we have generalized the statistical model to allow us to estimate simultaneously the parameters of probabilities determining in each month whether or not a woman contracepts and whether or not she becomes pregnant, under the assumption that both contraception decisions and conception probabilities contain unmeasured persistent components.

The third component of our project is to use the statistical methodology we have developed in order to provide empirical tests of our economic theory of fertility behavior, using data from the 1965 Princeton National Fertility Study. To date, our empirical resuls are limited. In the cited papers, we obtained maximum likelihood estimates of the monthly probability of conception in the first birth interval for groups of contraceptors and noncontraceptors separately, using a statistical model in which the distribution of unobserved components was assumed to be normal. We found that in each group about half of total variance was persistent and that parameter estimates changed considerably when we explicitly allowed for heterogeneity, but evidence about the effects of economic variables was inconclusive. Early results from estimates of the Dirichelet model appear promising, but it is premature to report any concrete findings.

In the coming year, we hope to make progress on all three fronts—the theoretical model, statistical methodology, and empirical work—and expect several additional papers to emerge from this project.

James J. Heckman
Robert J. Willis

The Timing and Spacing of Births and Women's Labor-Force Participation: An Economic Analysis

My theoretical model assumes that couples attempt to control the timing and spacing, as well as the number, of childbirths. Child-related activities are assumed to be time-intensive; their relative cost is higher the higher the price of the time inputs (P_t). Because women with more education have a higher P_t, close spacing of births produces more of a saving for them. Early timing of the first birth (B_t) produces more of a cost reduction for educated women because their P_t rises more steeply over their lifetime than for less well-educated women. Considerations of market skill depreciation reinforce these effects.

Families with high incomes are hypothesized to have their first child sooner and to space subsequent children more widely, to achieve more child quality, and to consume more child-related activities. Couples with a steeply rising income profile in the early adult years are predicted to have their first children later.

The empirical tests of the hypotheses, based

on data from the National Fertility study and the National Longitudinal Survey, showed that women with more education have B_1 sooner after leaving school than less well-educated women; also, an additional year of schooling raises the age at B_1 by only about one-half year. The higher the wife's education, the shorter the total interval between B_1 and the last birth (B_n), given family size. The effect is even stronger if completed fertility is not held constant, for more highly educated women also have fewer children.

The husband's education, used as a proxy for the slope of the income profile given his current income, had the expected positive effect on the interval from the wife's leaving school to B_1 and on her age at B_1 given her education. The effect of the husband's education on the total interval is ambiguous. In the data set with adequate income information (NLS), the effect of higher income is to shorten the interval from the wife's leaving school to B_1 and to lengthen the total interval from B_1 to B_n.

The price of time and the level of income affect not only the number, timing, and spacing of births, but also women's labor-force participation. Women with more education worked during a greater part of the intervals from school to marriage and from marriage to B_1. The probability that a woman will work after having one or more children was found to be higher the more education she has and lower the more education and income her husband has. A woman who has had children but expects to have more is more likely to enter the labor force the higher her husband's income, the more children she has, and the farther apart she has them. If a woman does not work until after B_n, additional education shortens the interval from B_n to the time she enters the labor force; if her husband's income is high, she waits until the last child is older before entering the labor force. Also, the longer the interval from first to last birth, the sooner the woman enters the labor force after her last birth.

Since this work was completed, certain inadequacies in the data have been discovered; apparently the work experience after B_1 for many women was inadvertently omitted from the Parnes data tapes by the Census Bureau. Post-B_1 labor-force participation will be reex-

amined when the corrected tapes become available.

<div style="text-align: right">Sue Goetz Ross</div>

Marriage and Social Interaction

During the last year I completed a paper titled "A Theory of Social Interactions" that will be published in the *Journal of Political Economy*. A first draft was completed many years ago as part of an attempt to provide a theoretical rationale for an NBER study of philanthropy. The present paper analyzes more generally the interaction between the behavior of particular persons and different characteristics of other persons. Although social interaction is emphasized in the contemporary sociological and anthropological literature, and was considered the cornerstone of behavior by many nineteenth-century economists, it has been neglected in modern economic literature.

Interactions among members of the same family receive the greatest attention. The "head" of a family is defined not by sex or age, but as that member, if there is one, who transfers general purchasing power to all other members because he cares about their welfare. A family with a head is a highly interdependent organization with the following properties:

A redistribution of income among members would not affect the consumption or welfare of any member because it simply induces offsetting changes in transfers from the head. As a result, each member is at least partially insured against disasters that may strike him.

Not only the head but other members as well act "as if" they "loved" all members, even when they are really selfish, in the sense that they would maximize not their own income alone but family income. As it were, the existence of a head economizes on the amount of true love required in a family.

A family would act "as if" it maximized a consistent and transitive utility function subject to a budget constraint that depended only on family variables. This utility function is the same as the head's, not because he has dictatorial power, but because his concern for the welfare of other members integrates all their utility functions into one consistent "family" function.

Transfers from parents to children in the form, say, of schooling, gifts, and bequests tend to be negatively related to what the income of children would be relative to their parents in the absence of these transfers. Therefore, the relative income of children *inclusive* of transfers could be unrelated or even negatively related to these transfers. Consequently, one cannot infer anything about the stability across generations of economic or social positions simply from knowing the relation between parental position and the amount of income transferred.

I have also been continuing my research on developing an economic analysis of marriage. Two papers setting out the basic theoretical framework were published during the last year in the *Journal of Political Economy* "A Theory of Marriage: Part I" (July–August 1973), and "A Theory of Marriage: Part II," Special Supplement (March–April 1974). Both are also included in the volume *Economics of the Family: Marriage, Children, and Human Capital,* ed. T. W. Schultz.

Elisabeth Landes and I have started a study of divorce and separation, building in part on the analysis developed above. We report on this study in the section that follows.

Gary S. Becker

Marital Instability

We are embarking on a study of the causes of marital instability; that is, of separations and divorce. Our analysis combines aspects of the theories of search, investment in "specific" capital, and of marital formation (see Becker, "A Theory of Marriage," *Journal of Political Economy* [July–August 1973 and March–April 1974]). Some tentative implications of the analyses about instability are:

1. Marriages that deviate most from an "optimal sorting" with perfect information would be more likely to dissolve.

2. Greater marriage-specific investment, such as children or skills at particular nonmarket activities, should increase the "cost" of dissolution, and thereby discourage it.

3. The frequency of dissolution should be positively related to the likelihood of remarriage, say measured by the number of eligible persons

with relevant age, education, and other characteristics.

These hypotheses are being tested with data from the 1967 Survey of Economic Opportunity. We have been analyzing sorting patterns by duration of marriage, arguing that couples who sort less well are less represented at later durations since they dissolve their marriages. We are planning a more complete analysis of these data and also are trying to acquire additional data sets, such as the 1970 National Fertility Study and the Office of Economic Opportunity follow up to the SEO study. The characteristics of the first spouses of persons who have separated or divorced are not available in the 1967 SEO survey, but are in these two data sets.

Gary S. Becker
Elisabeth M. Landes

Male-Female Wage and Employment Differences

I have completed a study of differences in wages and employment by sex titled "Male-Female Differences in Wages and Employment: A Specific Human Capital Model." In this paper I employ the theory of specific human capital to analyze the effect of differences in male and female labor-force behavior on a firm's incentive to invest in workers. Although the model is formulated in terms of sex differences, it is applicable to any two groups who differ in labor-force behavior. Therefore, empirical analysis of aggregate occupational data is carried out both for white females relative to white males and for black males relative to white males, with qualitatively similar results. These samples are drawn from the 1967 Survey of Economic Opportunity.

The model reveals that wage differentials can exist between males and females in the absence of any tastes for discrimination. Empirical estimates of the importance of specific human capital in determining wage differentials are quite large, ranging from about 45 to 100 per cent, with strong reason to suspect the lower number to be an underestimate.

The paper was accepted as a Ph.D. dissertation at Columbia University and is presently being circulated as NBER Working Paper No. 29.

Elisabeth M. Landes

Human Capital Formation at Home and in School

During the past year, I have revised and extended my paper, "Home Investments in Children," which describes my research on the investments made in children's human capital by families. I estimated, for males in the Terman sample, a recursive model that traces the impact of home investments on measured ability, final level of schooling, and earnings over a thirty-year period. (This sample was described in last year's *Annual Report.)* The ability and schooling equations were estimated for females in the sample, as well. This paper was presented at a population conference sponsored by the NBER and the Population Council and was published in the March–April 1974 *Supplement* to the *Journal of Political Economy.*

At the 1973 annual meetings of the American Economic Association I presented a report on my study of differences in women's allocation of time by education. The major finding is that, in spite of their greater opportunity cost of time, which leads them to spend less time in most kinds of household production, more highly educated women spend more time in child care. This paper, "Education and Home Production," was published in the *Papers and Proceedings of the American Economic Association.* A related paper focusing on differences in female labor-force participation by education, "Education and the Allocation of Women's Time," will be appearing this year in *Education, Income and Human Behavior,* a volume of articles to be published by the Carnegie Commission on Higher Education, and the NBER.

To extend my study of the investments that families make in their children to a broader-based sample, I am currently studying the effect of the quantity and quality of parental time and goods inputs on the achievement of children from low- and moderate-income families.

I am also analyzing the monetary returns from the intensity of human capital investments. I have written a paper in which I argue that the number of years spent in school adequately characterizes neither the inputs nor the outputs of the process of human capital acquisition. I show that the rate of return from schooling investments cannot be identified from the linear regression of log incomes on years of schooling, even given the knowledge of the average ratio of expenditures to full-time earnings. To identify the rate of return from this kind of cross-sectional regression, the correlation between intensity and years of schooling must be known.

During the past year I have developed the cost of schooling data that are necessary to measure the intensity of schooling for the Terman sample, which was referred to above. In this body of data, the correlation between intensity and extent of schooling is positive, and thus the unadjusted rate of return is biased upward. Comparing lifetime earnings of the Terman sample to lifetime earnings of persons of equivalent age and years of schooling, but of average ability, suggests that one of the ways in which high ability affects earnings is by allowing greater intensity of schooling, and thus earlier entry into the labor force. These results are discussed in NBER Working Paper No. 49.

Arleen Leibowitz

Trends in Female Labor Supply

We have begun a study of trends in female labor supply. Our research began with an examination of the movements in female market activity that occurred during the 1960s, using the 1960 and 1970 U.S. census survey. We then constructed a time series by linking up yearly cross-sections from the CPS data. There apparently have been significant changes recently in the time-series movements. During the postwar period and 1950s, the largest increases in labor supply occurred among the most educated women and among women in their middle ages. In the 1960s, however, it was the youngest women (ages 20–29) and the least educated who have exhibited the greatest increase in hours worked.

For descriptive purposes, these cross-sectional data sources are adequate, but for analytical work we will use both the mature women's and the young women's National Longitudinal Surveys. These tapes contain a woman's work history between schooling and marriage, between marriage and the birth of her first child, and beween the birth of her first child and the time she began her current job. These data will

enable us to examine trends in labor supply during those important life-cycle intervals.

Work on the theoretical front is proceeding more slowly. We hope to be able to disentangle, at a theoretical level, factors that alter labor supply because of cohort, life cycle, and calendar-year effects. Smith has already developed a life-cycle theory of labor supply for married women. We now plan on developing a model of endogenous technical change in the household sector.

James P. Smith
Robert Willis

Black-White Trends in the Sixties

It is now well-documented that during the 1960s black incomes rose relative to white incomes. The existence of the 1-in-100 census for 1960 and 1970 permits, for the first time, a detailed analysis of this improvement in the economic position of blacks. Recent work by Welch suggested that the returns from schooling are more valuable to younger, more recent entrants into the labor force. These trends have existed (at least) since the 1930s, and because there are cohort effects for whites as well as blacks, much of the improvement in incomes may be rooted in improved relative quality of schools attended by blacks rather than declining market discrimination. By examining the returns from schooling in the 1-in-100 samples of the 1969 and 1970 census surveys, we hope to disentangle cohort effects from whatever effects may have resulted from efforts of the federal government to reduce market discrimination. The state identification data also enable us to study the relative trends in schooling quality in the South and nonsouthern regions.

One part of our work involves a descriptive comparison of the earnings distribution among black and white males. A number of characteristics of these distributions, such as mean, variance, skewness, etc., will be studied. Apparently there exists more inequality among black male earnings than white male earnings. The reduction in the between-group variance between 1960 and 1970 has been offset by an increase in the within-group variance, especially among white males. A paper on our work was presented at the May 1974 Conference on Research in Income and Wealth.

James P. Smith
Finis Welch

The Distribution of Family Earnings

I have continued my research on the distribution of family earnings and have extended it in a number of directions. In most studies of income distribution, economists have concentrated exclusively on the distribution of personal incomes, and in particular, on the income distribution of males. My work will concentrate on the distribution of *family* earnings. Before one can understand the variance in family earnings, earnings must be separated into its wage-rate and hours-worked components. Changes in family earnings reflect age variations in both hourly wage rates and yearly working time of each family member and the covariation between spouses in wages and hours. The positive covariance between wages of spouses leads to greater inequality in family earnings whereas the negative correlation in the hours worked of both members is in favor of equality. On balance, the covariance of husband's and wife's earnings is negative.

I am developing three aspects of the theoretical model. The human capital investment models should explain the age-wage pattern for the husband and wife simultaneously. I am developing the theory of the optimal life-cycle human capital investment pattern for married men and women. On the labor-supply side, I am extending the theoretical model developed in my thesis. This model has been useful in explaining the life-cycle time allocation of married men and women. 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 now using three data sets for the empirical work: the 1967 SEO sample and the 1960 and 1970 U.S. census surveys. The empirical work from these data sources is about completed, and I hope to add one longitudinal data set to complete the analysis. My work will ana-

lyze the distribution of family earnings for both white and black families.

<div style="text-align: right">James P. Smith</div>

Public Finance Aspects of Family Behavior

In addition to finishing up several papers started before I joined the NBER staff, I have been investigating the effects of taxes on human resources (including the tax treatment of the family, and taxation and human capital accumulation).

A paper titled "Tax Incidence in an Economy with Human Capital Accumulation" is near completion. This paper examines how taxes on labor and/or capital income affect the long-run functional distribution of income. The primary analytical result is that the long-run changes in wage and profit rates depend on the rate and wage elasticity of human capital accumulation as well as physical capital accumulation, the elasticity of substitution, and other factors. For example, a payroll tax traditionally believed to be borne by labor may be partially shifted to capital through a decline in human capital accumulation that decreases the future productivity of physical capital. I am currently working on some numerical examples of the net effect on long-run incidence of including such human capital considerations in the incidence analysis. I am in the process of complementing this analytical work with an empirical study of the effects of taxes on private household capital (nonhuman and human) formation.

The study of the tax treatment of the family extends a previous paper, "Optimal Tax Treatment of the Family," beyond static labor-supply considerations to the effect of taxes on human capital accumulation and optimal income tax schedules in the case of a joint distribution of abilities of husbands and wives. The conditions under which taxing husbands and wives at the same rate (as under the current income splitting provision) is desirable are derived, as are the conditions under which the husband or the wife should be taxed most heavily. Also derived are rough estimates of the dead weight loss from the current income tax owing to the distortion in the work-leisure choice and the distortion in intertemporal consumption patterns.

I am also working on a variety of miscellaneous projects relating to social security and to wages, experience, and job turnover.

<div style="text-align: right">Michael Boskin</div>

4. FINANCIAL AND INDUSTRIAL INSTITUTIONS AND PROCESSES

Financial Institutions and Processes

Introduction

As was the case last year, the several projects that make up the study of The Effects of Inflation on Financial Markets are the major elements in the Bureau's financial research program. In addition, there are separate reports here on the studies of Individual Investor Portfolio Performance and The Influence of Structural Variables on Monetary Behavior in Country Cross Sections. A new study of The Financial Management of Multinational Firms is discussed below in the section dealing with International Studies.

Several reports, aside from those mentioned in the separate sections below, are moving toward publication. "The Yield on Insured Residential Mortgages" by Anthony J. Curley and Jack Guttentag, the last from the Study of Interest Rates, financed by the American Life Insurance Association, will appear in the first issue of the Bureau's new journal, *Explorations in Economic Research.* "The Impact of Monetary Policy on the Allocation of Bank Credit," by David Kresge, a microeconomic study of the behavior of the commercial banking industry in 1965–67, has been approved for publication and will appear in a forthcoming issue of *Explorations in Economic Research.* Part of the financing for Kresge's study was provided by the American Bankers Association and the Federal Reserve Bank of Boston. Leo Troy's manuscript on "The Finances of American Unions," which originated in the preparation of the monograph on *Institutional Investors and Corporate Stock* for the

Securities and Exchange Commission, has also been reviewed by the staff and is being revised by the author.

Robert E. Lipsey

The Effects of Inflation on Financial Markets

In 1972, with a grant from the American Life Insurance Association, we began a study to determine some of the consequences of inflation for financial markets. The study is now nearing completion and papers reporting the results have been published, are in process of publication, or are in preparation.

Thomas Sargent analyzed the effect of inflation on interest rates with emphasis on the problems of properly measuring the effect. His findings were published in the proceedings of the Universities–National Bureau Conference on Secular Inflation as a supplement to the *Journal of Money, Credit and Banking*, February 1973. He also published some byproducts of his work on this subject as "Rational Expectations, the Real Rate of Interest, and the Natural Rate of Unemployment" in *Brookings Papers on Economic Activity*, No. 2 (1973); "The Fundamental Determinants of the Interest Rate: A Comment" in *Review of Economics and Statistics*, August 1973; and "Rational Expectations and the Dynamics of Hyperinflation" (with Neil Wallace) in *International Economic Review*, June 1973. Sargent is preparing a short nontechnical paper summarizing his results.

I brought together the data on stock values and consumer and wholesale prices for a variety of countries to study the effect of inflation. These findings were published as a supplement to the *National Bureau Report*, No. 13, March 1974.

Lester Taylor summarizes below his analysis of the effect of inflationary anticipations on saving in the United States, using both household surveys and aggregate time series. His report on "The Influences of Price Expectations on Household Saving" is slated for publication in a forthcoming issue of *Explorations in Economic Research*.

Stanley Diller analyzed the determinants of convertible bond values. The relevance of convertible bonds to this project is that their pre-

miums over straight-bond and stock values reflect the degree of uncertainty about future prices of stock and bonds, and the uncertainties are presumably exacerbated by inflation. A draft of his report, outlined below, is being circulated for comment.

A major part of the project is a study by John Lintner, in collaboration with Thomas Piper and Peter Fortune, to analyze the influence of inflation on investment and loan policies of financial institutions in recent years. They have collected data on equity kickers and other aspects of such loans thought to reflect inflation and interviewed the officers of a variety of financial institutions to examine changes in perceived investment policy. Key findings are reported below.

They also report on a study of the effect of inflation on short-run movements of stock prices. A preliminary discussion of the problem and some of the findings were published in last year's *Annual Report*.

Phillip Cagan

Investment Policies of Major Financial Institutions Under Inflationary Conditions

During the past year, our work on the impact of inflation and of expectations of further inflation on the portfolio investments of major financial institutions has been focused primarily on the changing patterns of use of various forms of income participation on mortgage loans since 1965, the use of and experience with equity kickers on privately placed debt instruments and public issues of debt, and further development of our analysis of the forward commitment process, as well as our investigation of the impact of inflation on common stock prices and the returns on equity investments.

After a thorough search of the literature, we completed our field work on the use of income participations (IP's) of various types by different major lenders on income property mortgages. This work has included interviews, each based on a detailed questionnaire, with senior officers of twelve life insurance companies, five major savings banks, four large real estate investment trusts (REIT's), four commercial banks, six regulatory agencies and trade associations, seven developers with varying scales of operations,

and three mortgage bankers—over fifty interviews in all. We have undertaken to distinguish the effects of tight money *per se* from the effects of inflation and expectations of further inflation, among other things, by determining the lender's assessment at the time of the loan of the value of the IP and the basis of that judgment. Along with our primary concern with studying the characteristics of the use of income participations, we are also concerned about the basis for rationing credit in periods of tight money, particularly whether credit is rationed solely on the basis of the economic viability of the project. For this purpose we have consequently examined cases in which money was not advanced.

The IP's used have taken various forms: percentages of gross rentals, percentages of net property income (defined in a number of ways), percentages of the excess of gross over some base figure, purchases and leasebacks (with escalator rental clauses), and/or joint ventures. We have sought to gain an understanding of the trade-offs among these different forms of IP's as perceived by different lenders—and by borrowers—at different times on different types of property, and how much was given up in contract rate, lengthened maturity, or other terms in the use of IP's rather than a standard flat-rate mortgage. The perceived trade-offs and estimates of the net value of the IP (over the contract rate that *could* have been obtained) varied in a rather systematic way among lenders, types of property, and strength of developer or borrower, as well as with credit market conditions and the lender's competitive position in the market. In the period up through 1970–71 there was an evolving pattern of change in the predominant form of IP being used, with marked increases in the use of purchase-leasebacks and joint ventures as a means of getting an equity return on what was regarded as being (in substance) "equity money" and avoiding usury ceilings, and also as a means of increasing, on a mutually satisfactory basis, the fraction of total cash costs being advanced. One of the clearest and most important effects of inflation in this market was the rapid development of the REIT's as a major factor in the market, and their presence as major lenders in the more recent periods of high rates and tight money goes far to explain the relatively infrequent use of IP's in 1973–74 after their prevalence in 1968–71. A draft of the text covering our study of income participations will be ready for review this fall.

Similarly, our study of equity kickers cuts across different types of institutions important in the private placement market. This research is based on interviews with the lenders, borrowers, and agents involved in a selected representative sample of twenty-four financings to determine the factors on both the lenders' and borrowers' side that contributed to the use (or rejection) of a particular type of kicker on specific deals, as well as an extensive tabulation of data drawn from public sources, mail questionnaires sent to 300 private placement borrowers, and an extensive search of the literature. All the literature search and data collection has been completed, the interviews are nearing completion, and preliminary findings will be available by the fall of 1974.

Another important avenue through which inflation can influence the investment policies of major financial institutions is through its impact on the forward commitment policies of life insurance companies and large savings banks. The broad conclusions of our field work and econometric analysis of these commitment policies were summarized in last year's progress report. Further work has extended the analysis and broadened the generality of the results obtained. Forward commitments on different types of assets (private placements, nonresidential mortgages, multifamily and single-family residential mortgages) are undertaken to produce a desired balance in the asset portfolio *after* the commitments are drawn down. Apparently for the first time in the literature, we have developed a model of these underlying asset-portfolio preferences based on the evident concern of life officers to match the maturities of their assets as nearly as possible to the futurity of their liabilities as well as their observed risk-aversion and hence on their assessments of the relative returns and risks of the different securities and their premium on diversification.

These desired portfolio proportions, together with estimates of total assets in the future and the distributions of take-down periods on forward commitments on different types of mort-

gages and loans, then determine a *desirable average* ratio of forward commitments of each type to the expected quarterly flow of investable funds over a planning period that extends as much as three years or more into the future. But within any planning period, the pace of forward commitments can be stepped up or dropped below this average ratio to expected investable funds in order to take advantage of expected changes in interest rates. The results of our field work revealed the fact, overlooked in previous studies of forward commitments, that a substantial majority of the companies adjusted their commitment positions significantly on the basis of their interest rate expectations at various times between 1965 and 1972, but that several of the companies that had made such adjustments to a significant degree earlier in the period had not done so later. Our field work also indicated that all the companies throughout were risk-averse maximizers of their returns, although the emphasis had shifted from concern with the amount of income (or the level of the income stream) produced by the investments made to concern with the *rate* of return (or the "new money rate") obtained on the funds dispersed at any given time—and in some companies more recently to the *relative performance* of new money rates.

Models of the optimal scale of forward commitments under each of these risk-averse objectives have been developed and used to explain and generalize the changes in forward commitment policies observed in our field work. When interest rates were essentially stable (as in the early 1960s) and covariances between investable funds and interest rates were low, risk-averse maximizing behavior implies the essentially "fully committed" posture actually observed. Later, when interest rates were expected to rise (or fall), commitment positions would be cut back (or stepped up) as long as the uncertainty of the expected change in rates was not great and little advance allowance was made for covariance between available funds and interest rates. But our models also show that the optimal extent of the adjustment of forward commitment positions to any given expected change in rates will be smaller (and may readily become negligible) when uncertainties are greater and

covariances larger—as indeed occurred later in the period being studied when rates were higher, covariances larger, and bond markets more volatile. We also find that the changes in assessments of market conditions over the years were more important in explaining the changing commitment positions than was the shift from an "investment income" to a "new money rate" objective for risk-averse investors. The latter objective produces qualitatively similar results but in stronger form, because new money rates are subject to a negative skewness that does not appear in levels of investment income. Among other important conclusions, this theoretical work also shows that risk-averse companies that are seeking to maximize either their levels of investment income as such or the levels of their new money rates will choose a high forward commitment ratio, in the face of a (observed) strong negative covariance between investable funds and interest rates, *only if commitment rates are higher* than current or expected market rates for direct purchases. This conclusion is particularly important because it shows that commitment rates would be *higher* than current or expected market rates (for direct investment) *even if* forward commitment markets were purely competitive in the strictest and most ideal sense and no lender had any "market power" whatsoever. The fact that commitment rates are usually higher than current market rates is *not prima facie* evidence of market power *per se.*

A draft of the first chapter of a proposed monograph on Inflation and Common Stock Prices was published in Section I of last year's *Annual Report.* The latter part of this paper generally described our continuing research on these important problems. Later work includes a manuscript on the Implications of Price and Wage Inflation for (Gross) Corporate Profits. In this study, we have reestimated equations for productivity, order-backlogs, and unemployment for the U.S. data for the first quarter of 1954 to the third quarter of 1971 in terms of the level and various distributed lags and differences in X^* (the ratio of real GNP to capacity) and reestimated price and wage equations in terms of these variables and lagged prices and wages. The statistical properties of the resulting equations compare favorably with those in major

arge-scale econometric models and previous academic literature. This set of estimates of the econometric structure of this subsector of the economy is then used for a set of dynamic simulations of inflationary experience. The "null" simulation holds X^* constant (at a level consistent with a natural rate of unemployment of 5.2 per cent) and yields a steady growth in the economy with zero inflation in prices and wages rising only with increases in productivity. Then starting from the stationary state we simulate (1) the results of a ramp increase over eight quarters in X^* (to levels consistent with a 3.3 per cent unemployment rate), which is then held; (2) an "upside shock" involving the same ramp increase in X^* over eight quarters, with X^* held stable for four quarters, and then decreased over an additional eight quarters to the original level and then held at this "stationary state" level until prices and wages finally stabilize; and finally (3) a set of "cyclical shocks" with X^* following the pattern of the upside shock simulation, but in which capacity utilization is progressively reduced various levels below the noninflationary norm and then gradually returned to the stationary state and then maintained. In each simulation the time paths of prices, nominal and real wages, unit labor costs, gross margins, real gross unit profits, and gross profits are traced and analyzed. The results of these simulations confirm how difficult it is to offset the momentum of an established pattern of inflation—in particular, merely bringing capacity utilization back to what *would* have been noninflationary levels is not enough to eliminate continuing inflationary pressures as much as five or ten years later. Significant declines in utilization *below* what would have been noninflationary norms are required to eliminate an inflation by fiscal means; and although gross profits are initially increased even in real terms in the earlier stages of an inflationary cycle, they first stabilize and then decline very sharply in both nominal and real terms for substantial periods before they begin to recover gradually and asymptotically to the real levels they would have reached in the absence of the intervening inflationary sequence. One byproduct of our analysis is to establish the very much smaller fluctuations in real wages and labor compensa-

tion than in money values over the inflationary cycle. These implications for the relative timing and severity of the response of prices and wages will be published in a separate paper, since conflicting results on whether real wages rise or fall in inflation have been reached in earlier studies by a large list of distinguished authors.

The *cyclical* changes in corporate earnings over an inflationary sequence are largely dominated by the fluctuations of *gross* profits just described. But the *net* incomes being capitalized in the stock market are also burdened by the growing and cumulative costs of rising interest charges (until long after interest rates on new issues have again receded), and also by the cumulative tax and financial effects of tax liabilities based on historical rather than reproduction costs—an effect which also continues *beyond* the end of the inflation by a period depending on the life of the capital stocks being used. Theoretical and econometric analyses of both these further effects on corporate earnings are well under way.

Models of portfolio adjustments between holdings of stocks and bonds and short-term funds when the returns on each depend on expected inflation, and related models of shifting capital market equilibria with market clearing equations for each interrelated sector, are being developed. These frameworks, after drawing on the results of our other work on the effects of inflation on gross and net earnings, dividends, and interest rates, are being incorporated in a new quarterly model of stock market prices that explicity incorporates interactions with other sectors, as well as the effects of inflation and inflationary expectations.

John Lintner
Thomas Piper
Peter Fortune

The Influence of Price Expectations on Household Saving

The purpose of this study, which is completed and currently awaiting publication in *Explorations in Economic Research,* has been to examine the influence of personally held price expectations on a household's saving and the composition of its portfolio. Aggregate time-series data from the National Income and Flow-of-Funds

accounts have been analyzed, as well as two large bodies of microsurvey data—namely, the Consumer Anticipations Survey conducted by the Bureau of the Census in close collaboration with the NBER in five six-month waves in 1968–70 and the panel survey of its members conducted by Consumers Union during the late 1950s.

The findings with respect to price expectations cluster at two extremes. The time-series results unambiguously point to price expectations having an impact on the amount that households save and on the way that they structure their porfolios. In particular, the time-series results show that expectations of inflation induce households to save more. The results from the two microdata sets, on the other hand, are weak and mixed. The CAS results provide mild support for the Katona–Juster hypothesis that expectations of inflation lead to an increase in saving via an increase in uncertainty and, in addition, suggest that price expectations are of most consequence to households with moderate wealth. On the other hand, nothing conclusive at all emerges from the CU sample.

Finally, it has become increasingly clear through the course of the study that the price expectations data that have been analyzed are markedly deficient. I do not mean this as criticism of the surveys from which the data were obtained—these surveys were designed for purposes other than the analysis of price expectations—but only in terms of lessons for the future. In particular:

1. Analysis of the price expectations data in both the CAS and CU samples indicates that the distribution of price expectations data varies markedly depending on which member of the household was queried. Clearly, the expectations that are relevant are those of the one responsible for the decisions that are made. Future endeavors in collecting price expectations data must accordingly make certain that the expectations obtained are those of the decision maker(s).

2. Efforts should also focus on obtaining estimates of the confidence with which price expectations are held. Obtaining this additional information in a usable form is crucial and must be given high priority.

3. Finally, future endeavors should also elicit information on whether near-term price changes are expected to be permanent or only temporary.

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

Convertible Bonds

I am at work on a revision of a complete draft of the study's report, which recently circulated among a limited group.

The report devotes approximately equal lengths to a theory of convertible bond values and to empirical tests of the model. Apart from its underlying stock and straight-bond values, the most important influence on the value of a convertible bond, in the study's model—as well as in most other models—is the *variability* of the underlying stock and straight-bond values. Variability often is associated with the riskiness of an investment. By making certain simplifying assumptions, it is possible to collapse the model into an equation that relates the value of the convertible to the observable values of the underlying stock and straight bond and to the maturity of the bond, as well as to an unobservable measure of variability. Equating the value of the convertible given by this equation with the observed value and solving for the implied variability, it is possible to obtain a measure of the risk associated with a given security at a given time. With the use of various averaging schemes, one can partition the risk associated with a particular security from that of a particular time. To the extent that activity in convertible bonds—whether pricing, trading, or new issue—reflects concern over inflation, this reflection should be manifest in the intertemporal variation of the risk measure. However, there is no way to separate the influence of inflation on the risk measure from other influences.

The empirical section of the report involves comparisons between the inferred risk measure and other measures of risk as well as various statistical tests of the plausibility of the inferred measure. In addition, I attempt to separate the positive influence of the variability of the stock on the value of the convertible from its influence on the riskiness of the convertible and resulting negative influence on the value of the convertible. In this connection the study reveals that the

average influence of a unit increase in the standard deviation of the stock on the net value of the convertible is one-third as large as it would be if the increased riskiness of the convertible were ignored.

The inferred measure of risk is somewhat sensitive to various assumptions made to facilitate the computation, and part of my work is to determine the degree of sensitivity of the measures actually used to the assumptions that were made. This sensitivity analysis deals separately with the following assumptions in or possible additions to the original empirical work: (1) normal versus lognormal distribution of prices; (2) inclusion of the effect of the convertible's own variance on its value and through that factor on the inferred variability of the stock; (3) the inclusion of more variables in the convertible bond model, such as trend of stock prices and discount rates for stock, straight bond, and convertible; (4) the influence of the option to convert before the bond matures. (In most models this option is overlooked.)

Stanley Diller

Individual Investor Portfolio Performance

Although researchers have directed a great deal of attention to the investment behavior and portfolio performances of institutional investors, there are virtually no hard data available on the corresponding circumstances of an individual who manages his own portfolio. His behavior has been simulated or inferred from general market price movements, rather than observed directly. My study seeks to remedy that deficiency by examining the portfolio and transactions history of a large sample of actual individual investors over the period 1964 through 1970, drawn from the accounts of a large national retail brokerage house. The portfolio record, which is a complete listing of transactions in and holdings of individual securities, was supplemented by a questionnaire survey of the group.

The questionnaire yielded information on the demographic characteristics, investment objectives, decision processes, market opinions, and total asset holdings of the individuals involved. A paper titled "The Individual Investor: Attributes and Attitudes," which summarizes the nature of

the study and certain of the preliminary findings, was presented at the annual meeting of the American Finance Association in December 1973 and appears in the May 1974 issue of the *Journal of Finance.* In process at the moment are further analyses of the questionnaire data, including cross-sectional investigations of patterns of investment behavior within the sample and an examination of the profile of asset holdings by age and income categories. Calculations of investment returns, and their comparison with the performance of institutions and market indexes, are proceeding in parallel. Results in this area should be available in 1974.

Wilbur G. Lewellen

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

Although much of the differences in monetary behavior of various countries can be attributed to different national institutions and preferences, there are common characteristics that bear investigation. To accomplish such an investigation, we have selected and examined cross-sectionally monetary and real sector variables for a set of countries. Alhough avoiding many of the difficulties associated with regression analysis of time-series data, the cross-sectional study suffers from the immense difficulty that attends attempting to control for the influence of national peculiarities. Despite these problems, the cross-sectional analysis does permit examination of useful hypotheses relating to the demand for and supply of money. We are now completing attempts to identify the most significant variables influencing the demand for monetary reserves, inflation, and economic growth.

The data have already yielded some interesting conclusions. Analyses of the demand for and supply of money have been cast in a market framework. Significant determinants of demand include per capita income, openness, interest rates, and inflation. As might be expected, the cross-sectional data offer very little assistance in understanding variations in interest rates. However, despite measurement problems, these data have provided considerable insight into variations in the money supply. The data are consistent with the hypotheses that the interest

elasticity of the supply curve is far from infinite, and both openness and the level of development affect the quantity of money in existence.

One study of the interaction of gross national product with its components and with money indicated that fiscal and monetary policy were both important influences on the level of gross national product. This conclusion was unaffected by consideration of the level of development. This study has been submitted for publication in a volume in honor of Felipe Pazos, edited by Carlos Diaz-Alejandro at Yale University.

The project is going forward with some changes in personnel since Henry Wallich's appointment to the Federal Reserve Board. Mrs. Mabel Wallich and Francis X. Splane, Assistant Professor of Economics at Capitol Campus of The Pennsylvania State University, have joined the study.

<div align="right">Henry C. Wallich
Francis X. Splane
Mabel Wallich</div>

Industrial Institutions and Processes

Introduction

This year, research in industrial organization at the National Bureau may be classified in three categories:

1. Studies of the determinants or consequences of technical change.
2. Studies of advertising.
3. Selected studies of market organization.

In the first category are a new study by myself of the diffusion of product innovations, the continuing research of Henry Grabowski and Dennis Mueller on rates of return to research and development outlays, and the work of John Meyer and Alexander Morton on changes in railroad productivity. In the second category are Grabowski's study of returns to advertising outlays and Phillip Nelson's research on the role of search and experience as sources of consumer information and their effect on the volume of advertising outlays.

There are also several studies approaching completion on selected topics in market organization. I prepared a manuscript on the role of

concentration as a determinant of profit rates and Guy Herregat has been studying pricing strategies in the performing arts. In addition, two studies of product diversification, one by Thomas Wilson and another by myself, are currently in the manuscript preparation stage.

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

Returns to Firm Investment Outlays

Our main effort during the past year has been directed to estimating and comparing rates of returns from research and development activity and plant and equipment expenditures. Using a capital theoretic approach, a firm's earnings or cash flow is related to its capital stocks generated by its past R & D outlays as well as its past plant and equipment investment expenditures. The stocks of accumulated assets in any period are measured as weighted sums of past investment outlays. The time pattern of weights in turn depend on what assumptions are made about the nature of depreciation for each of these investment activities. In our empirical work, a number of variants in this regard are being studied.

In most of the models empirically investigated to date, we have assumed that both R & D and plant and equipment stocks depreciate at a constant (but not identical) proportional rate over time. In estimating the rate of return from these activities, the regression coefficients also provide an estimate of the rate of depreciation. However, a nonlinear iterative technique must be employed to obtain estimates even with this simple version of the model.

Our empirical work to date has been performed on an eighty-six-firm sample covering ten broad manufacturing classes. For this sample, R & D data from NSF survey questionnaires have been assembled for the period 1958 to 1966. Using these data and balance sheets and income data from the Compustat tape, capital stocks are generated as weighted sums of R & D and capital investment over this eight-year period. In addition, various assumptions about the size of initial capital stocks have been employed in our empirical work. This eighty-six-firm sample is then used to form cross-sectional

samples to estimate rate of returns and depreciation rates for these investment activities.

As one might expect, the rate of return estimates depend on how the sample of eighty-six firms is stratified, the time period covered, and more fundamentally, the assumptions made about depreciation and initial capital stocks. Despite this variability in the size of returns, a consistent finding in our initial work is that rates of return on R & D (net of depreciation) are usually significantly higher than those estimated for plant and equipment investment. This finding is consistent with the frequently expressed hypothesis that R & D activities are typically riskier than other types of investment activities. If this is so, one would expect a higher mean rate of return to R & D to compensate for the higher degree of risk.

In the coming year, we plan to evaluate several variants of our basic models. These allow for interactions among the stocks as well as other distributed lag patterns. In addition, we also plan to incorporate other types of investment activities (e.g., advertising expenditures) into the analysis.

In addition to this line of research, our paper investigating the relation between returns on investment and the sources of finance (i.e., internal means), which was discussed in last year's *Annual Report,* has been revised and submitted for publication.

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

<div style="text-align: right">Henry Grabowski
Dennis Mueller</div>

Marketing and Advertising

A first draft of a manuscript titled "Rates of Return to Advertising Investment Expenditures" is currently in preparation. This manuscript incorporates findings previously reported on advertising rates of return and depreciation rates estimated from several intraindustry studies. Over the past year, I also have examined the interindustry effects of advertising and have estimated industry demand curves for which relative advertising, relative prices, and disposable income are the main explanatory variables. I have estimated separate demand curves for roughly thirty industry classes, using time-series observations over the period 1956 to 1972. I employ various dynamic formulations for each industry regression. The relative effect of changes in advertising and prices on industry demand is a main focus of the interindustry analysis.

The full manuscript should be available for staff review in the near future. It is being prepared in accordance with the following outline:

I. Advertising and Economic Performance: Issues and Literature Review

II. Advertising as an Investment Decision: Theoretical Considerations

III. Rates of Return to Advertising: Intraindustry Studies

IV. Interindustry Effects of Advertising

V. Application and Conclusions

<div style="text-align: right">Henry Grabowski</div>

Consumer Information and Advertising

I have in past studies tried to show that the way consumers gather information about a product has a profound impact on the nature of consumer markets, in particular on advertising. There are two problems with these studies that I hope to remedy in this work. (1) My classification of goods into the experience or search categories depended to a considerable extent on my own prior judgment. (2) Both my analysis and empirical procedures were based on the assumption that a consumer gained knowledge about a particular good either through experience or search. I ignored the mixed case wherein certain properties of a good were ascertained by search then other properties were investigated through experience.

The basic theoretical variables—the utility variance investigated by search (the search variance) and the utility variance investigated by experience (the experience variance)—are not directly observable. But testable implications arise through the multiple implications of the theory. The greater the search variance, the greater (1) store clustering, (2) retail mark-ups, and (3) the percentage of print to total advertising expenditure. This implies a positive relationship among the three. Similarly, the greater the experience variance, the greater (1) concen-

tration ratios, (2) national advertising expenditures and (3) guidance. Since one predicts a negative relationship between experience and search variances, a relationship should emerge between the two sets of variables as well as within each set.

The richest body of data I am working with classifies advertising expenditures by brand and media for detailed industries. This allows extensive investigation of the pattern of print to total advertising expenditures as advertising expenditures increase. Rather strong predictions about these patterns by search and experience variance can be made, which means that the information role of advertising can be tested substantially.

Phillip Nelson

Diffusion of Product Innovations

During the current fiscal year, I began a study funded by the National Science Foundation on the diffusion of product innovations. There are two parts to the study. The first and largest part of the study seeks to assess the consequences of diffusion and the reasons for variations in the rate of diffusion over time. The second focuses on the characteristics of innovating firms.

I define diffusion as changes in the number of producers of a basically new product, starting with the introduction of the product and continuing until the market reaches maturity. The first part of the study has two objectives. One is the development of a model that explains the slope of the diffusion curve. Diffusion models have in the past dealt primarily with process innovations, and a different model appears to be appropriate for product innovations. The second objective is to determine the impact of diffusion on subsequent innovations and to measure the interrelations among diffusion, growth in demand, and price changes.

Progress to date for this part of the study has consisted primarily of data development. I have completed compiling annual changes in the number of producers for fifty-three major innovations, from the first commercial introduction of the product to 1972. For approximately thirty of these innovations, I have also compiled annual data on sales, prices, and number of pat-

ents issued and have gathered information on the major improvements in products or production processes subsequent to the introduction of the basic innovation. Data development will continue for the next several months.

In the second part of the study, I am trying to compare the characteristics of innovating firms with respect to managerial aggressiveness with the characteristics of (1) the same firms at a later point in their history, and (2) a randomly selected sample of firms that were late entrants in the same markets rather than innovators.

Managerial aggressiveness is associated in the analysis with two types of profiles: management policies that reflect risk preference rather than risk aversion, and policies that are expansionist rather than defensive. I am using factor analysis to identify risk preference, risk aversion, and expansionist and defensive policies. The specific variables are (1) rate of managerial turnover, (2) diversification, (3) changes in the debt-equity ratio, (4) rate of growth in sales, (5) the dividend payout ratio, (6) the ratio of depreciation to net fixed assets, (7) the age of the chief executive officer, and (8) his tenure in office.

Michael Gort

Profit Rates

A paper on the relation of profits to market concentration was presented by myself and Rao Singamsetti at the meetings of the International Association for Research in Income and Wealth in Rio de Janeiro, in January 1974. This paper has now been revised and will shortly be submitted for publication.

In this paper, we employ data for a sample of 507 individual firms, as distinct from data for industry aggregates. Moreover, we devise for each firm a weighted index of market concentration that takes into account the magnitude of the firm's activities in each of the markets in which the firm operates. The analysis is carried out with newly developed data that link employment information classified by industry for the establishments of a company (based on information from Dun & Bradstreet and Economic Information Systems, Inc.) with financial data from Compustat.

Our results conflict with most published studies of the relation of concentration to profit rates, but support those of George Stigler published by the National Bureau a decade ago.[1] Specifically, there appears to be no relation between concentration and the level of profit rates. On the other hand, there is far higher serial correlation in the profit rates of firms characterized by high concentration than there is for other firms. For firms associated with high market concentration, both positive and negative deviations from average profit rates are likely to persist far longer than for other firms. We attribute this condition to the existence of barriers to exit as well as barriers to entry in highly concentrated industries.

Research is continuing on the factors that contribute to stability of positive or negative deviations from average profit rates. Specifically, the movement to competitive equilibrium profit rates can be measured in the context of a model in which the change in the profit rate of a firm is a function of a sequence of past differences between the profit rates of the firm and the average profit rate for all firms. Using a distributed lag relation, we estimate the relevant "reaction coefficients" to explain the sources of variation in reaction coefficients.

Michael Gort

Diversification in American Industry

Preparation of a manuscript on this topic was temporarily interrupted by pressure of other work. However, we expect that a manuscript will be completed in the early fall of 1974. As indicated in last year's *Annual Report,* the manuscript will consist of the following 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

[1] George J. Stigler, *Capital and Rates of Return in Manufacturing Industries* (Princeton University Press for the NBER, 1963).

Henry Grabowski and Robert McGuckin are collaborating in this study.

Michael Gort

Mergers and Diversification

Research on this project was greatly facilitated by access to the microdata on individual businesses and corporations of the Profit Impact of Market Strategy (PIMS) Project of the Marketing Science Institute, together with an analysis of diversification (based on DUNS data) of fifty-five of the companies participating in the PIMS Project.

These data were utilized in a multivariate analysis of the impact of corporate diversification on profitability at the business level, and an analysis of how diversification interacts with the other determinants of the level of profit rates (concentration, market share, etc.).

The results obtained confirm the findings reported in recent papers by Miller and Rhoades, using industry data, that diversification has a positive impact on profit rates. Since these results appear to conflict with the considerable body of evidence suggesting that conglomerate mergers do not have a positive impact on rates of return, alternate variables measuring the importance of merger activity in the immediately preceding five-year period (1965–69) were also included in the analysis. The results indicate that although diversification continued to have a positive impact on profit rates, the extent of merger activity had a negative impact. This suggests, as a tentative finding, that conglomerate mergers may have a transitory negative impact on profits and a positive longer-term effect because the merger helps a firm to attain diversification.

Given these results and the results published by Miller and Rhoades, I felt it advisable to explore the relationship between diversification and profits using industry data. In this data base, I had to use cruder measures of diversification, but the industrial data base permitted me to analyze the role of diversification within the context of the interindustry model explaining profit rates previously developed by Comanor and myself.

These results confirm the earlier findings of Miller and Rhoades and provide support for the

results based on the analysis of the more detailed data.

In order to assess the growth of diversification over the period since the original Kaysen–Wilson sample was selected, I carried out an analysis of both published data from *Enterprise Statistics* and detailed firm data provided by DUNS. The *Enterprise Statistics* data indicate clearly that there has been a steady uptrend in diversification outside the principal industry of the firm. Furthermore, data on large-firm merger activity provided in the last two *Enterprise Statistics* publications (1963 and 1967) suggest that merger activity played an important although not predominant role in the increase in diversification.

Although changes in industrial classification have occurred over the 1954–67 period, these have been minor, with the exception of the major change in the standard industrial classification in 1957. As a result, we can get a reasonably clear picture of the growth of diversification since 1958 from these data.

In order to examine more detailed data and to construct more adequate measures of diversification, I constructed various diversification indexes utilizing the DUNS data for a sample of large firms. Unfortunately, it is impossible to get an exact comparison between the DUNS data and the census data for the 1954–58 period used in earlier work, so that the analysis is somewhat vitiated by problems of industrial classification comparability, coverage, and sample size.

I feel, nevertheless, that the comparison of the statistics of the sample of firms drawn from DUNS in 1970 with the sample of firms from the census in 1954–58 provides further evidence supporting the conclusion that diversification has increased dramatically over the 1958–70 period.

In addition, tabulations of the DUNS data enable me to provide a more recent cross-sectional view of the distribution of diversification and of the relationship among various diversification measures.

In the analyses discussed above, diversification and vertical integration have not been adequately separated, if at all. In order to determine the separate effects of diversification and vertical integration on profits, I have constructed an index of vertical integration based on input-output tables and DUNS data on the industrial distribution of company activities. This measure will be introduced into a multivariate analysis of profitability at the business level.

In addition, in order to determine the extent to which commonalities in marketing may be related to diversification, I have constructed a measure of market concentricity. This measure reflects the extent to which the sales of a diversified company are concentrated in particular types of markets—e.g., consumer durables versus investment goods, goods sold as intermediate products to food and beverage manufacturers versus goods sold to metal manufacturers, etc. This measure will also be introduced into the multivariate equation explaining rates of return on investment at the business level.

It now appears that it may be more appropriate for various sections of the study to be written as separate articles for publication in the two NBER journals rather than as a lengthy occasional paper, as was originally planned.

Tentative publication titles are as follows:

"The Measurement of Diversification." (A paper in which the focus is on the problem of measuring diversification, with a discussion of the advantages and disadvantages of different measures.) This paper will be submitted for publication in the *Annals of Economic and Social Measurement.*

"Diversification, Mergers, Size and Growth." (A paper in which the role of mergers in contributing to diversification, the relationship between size and diversification, and the breakdown of growth between diversification and growth within established markets are discussed. Much emphasis on the detailed analysis of the 1954–58 period will be presented here, but some reference to the later results will also be included.)

"Diversification and Profitability: An Analysis of the Determinants of the Rates of Return at the Business Level." (In this paper I will discuss the results reported above of the analysis of the mircodata at the business level.)

"Diversification and Profitability: An Interindustry Analysis." (This paper will contain the results of the extensions of the Comanor–Wilson model to incoporate diversification.)

The last three papers will be submitted to the

new NBER journal *Explorations in Economic Research.*

Thomas A. Wilson

The Economics of the Performing Arts

This research was contracted to the National Bureau by the Ford Foundation as a subproject of the Foundation's analysis of the present financial situation of the nonprofit live performing arts. The Foundation collected detailed income and expense accounts of some 180 nonprofit symphony orchestras, opera companies, theaters, and ballet and modern dance companies with budgets of $100,000 or over. The Foundation also took the responsibility for reconciling inconsistencies in the reported figures and for filling in missing observations.

At the National Bureau the accent has been on defining a structure that would allow for a better understanding of the factors entering the performing arts' demand and supply functions. It is hoped that the identification of these factors will permit policy parameters to be established and make it possible to measure through a simulation model the impact of reversals such as an increase in unit wage costs, an attrition of contributed income, and a doubling of ticket prices.

The first step of the analysis, consisting of the econometric estimate of the demand functions, has been completed. The model starts with the cash flow constraint of a performing art organization having to cover at least part of its season's costs by the sale of subscriptions. Accordingly, subscription ticket prices will be determined by a "cash flow target," the cost of performance, and past subscription attendance. Single-ticket price then is hypothesized to be a function of a targeted ticket income (defined as the ratio of single ticket income to potential ticket income), the cost of performance, past attendance, and a "discriminatory" variable consisting of the ratio of subscription attendance to total ticketed attendance. This variable is construed to measure how box-office prices vary with the success of the subscription drive. Finally, attendance functions for both subscription and single tickets were estimated and price elasticities approximated. These ranged over the years from 0.60 to 0.80.

In general, the results of the moving cross-sectional regressions are more than satisfactory, given the quality of the data. In most cases, the independent variables explain 75 per cent of the variance in the dependent variable and the F-values are strong. Some marked differences appear among the various art forms and these probably are technologically determined. Also, covariance analyses along size classes for a given art form resulted in statistically significant behavior heterogeneities that eventually relate to a hidden link between size and quality of the performances.

The next step will consist in estimating the cost functions and in defining the determinants of contributed income. The project is expected to be completed by the fall of 1974.

Guy Herregat

Railroad Productivity

Our study of railroad productivity was completed in November 1973. A report on the empirical essentials of that work has been submitted for publication in the new Occasional Papers journal, *Explorations in Economic Research.*

Our suspicion reported last year appears to be confirmed. The productivity index used by the U.S. Bureau of Labor Statistics, revenue ton-miles plus passenger-miles per man-hour, tends to overstate the probable growth of total productivity in the rail industry. After correcting for the substitution of capital for labor and the changing mix of railroad output, total productivity in the rail industry appears to have grown at an annual rate between 1 per cent and 2 per cent during the postwar years; this rate contrasts with the 5.7 per cent per year reported by the Bureau of Labor Statistics. Although our lower estimate of productivity growth in railroading is below the average rate for all private industry, 2.5 per cent per year, it is not out of line for an industry such as railroading, whose output has been stable or declining.

Our final report also describes how changes in freight markets, combined with sluggish productivity growth, have impacted the financial position of the railroad industry.

John R. Meyer
Alexander L. Morton

5. INTERNATIONAL STUDIES

Introduction

A major new activity undertaken by the National Bureau in the international area during the past year is the task it has assumed at the request of the National Science Foundation to assist in developing a program for cooperation with the U.S.S.R. in various types of scholarly exchanges pertaining to econometric modeling, applications of computer technology, and related topics. Plans being worked on for this program are outlined in the following report by Gary Fromm.

Expansion of the already impressive data base on operations of multinational firms is permitting an enlargement of the National Bureau's research in this area, particularly as related to the effects on international trade and the transfer of technology. This research is reported on by Robert Lipsey and his associates, Irving Kravis and Merle Yahr Weiss. Kravis and Lipsey are also adding to their earlier work on the construction of price indexes suited to the analysis of the effects of relative price changes on international trade flows.

With the project on Foreign Trade Regimes and Economic Development nearing completion, as reviewed below by the Co-Directors Jagdish Bhagwati and Anne Krueger, attention is now being given also to the preparation of two regional follow-up conferences. With additional funds provided for this purpose by the Agency for International Development, two such conferences are being planned, one in the Far East and the other in Latin America. The first, scheduled for December 14–16, 1974, will be held in Manila in collaboration with the Asian Development Bank, and the second, scheduled for January 6–8, 1975, will be held in Rio de Janeiro in collaboration with the U.N. Economic Commission for Latin America.

A new project with AID funding and directed by Anne Krueger iş on the relationship between trade strategies and employment growth. Although extensive research has been done both on trade policies and on employment problems of less-developed countries, surprisingly little investigation has been made of the bearing of the first one on the second. The new project is aimed at helping to fill this gap.

Recently published studies in the international area include that by Raymond Mikesell and Herbert Furth on *Foreign Dollar Balances and the International Role of the Dollar* (Studies in International Economic Relations No. 7) and the contribution by John Meyer and Guy Herregat to *The Diffusion of New Industrial Processes: An International Study* (published as No. XXIX in the series on Economic and Social Studies of the National Institute of Economic and Social Research, London). It is expected that George Garvy's draft on "Money, Financial Flows, and Credit in the Soviet Union" will soon be ready for submission to the Board of Directors.

Hal B. Lary

U.S.–U.S.S.R. Program on Scientific and Technical Cooperation

In May 1972 President Nixon and Chairman Brezhnev agreed on a program for U.S.–U.S.S.R. cooperation in the field of science and technology. Pursuant to that agreement, discussions were held between the Science Adviser to the President and Academician V. A. Kirilin, Deputy Chairman of the U.S.S.R. Council of Ministers and Chairman of the State Committee for Science and Technology of the U.S.S.R. Council of Ministers. These, in turn, led to the formation of joint working groups in a number of fields, including research in the field of chemical catalysts; application of computers to management; energy research and development; water resources; science policy; scientific and technical information; microbiological substances; forestry; meteorology; electrometallurgy; and special topics in physics.

The National Bureau has been asked by the National Science Foundation, the lead agency on the U.S. side, to help plan and coordinate the program in econometric modeling, economic programming, computer analysis applied to the economics and management of large systems, and related topics in the computer applications field. The program includes:

1. The exchange of information and summaries of research at the frontiers of the state-of-the-art in the U.S. and the U.S.S.R. in the form of

preprints, reprints, abstracts, journals, working papers, memoranda, proceedings, books, and so forth. The initial exchange was completed during March 1974.

2. Joint meetings in each country starting in 1974 and discussions of results attained in the two countries in seminars and conferences jointly organized and regularly scheduled for this purpose.

3. Exchange visits by specialists and scientists for fixed periods in appropriate institutions and participation in seminars, meetings, and conferences in which topics of mutual interest are to be discussed.

4. Joint pursuit of advancement in the state-of-the-art and presentation of research results on agreed-upon topics; such pursuit might take the form of joint research and writing and presentation of scientific papers where the interests of scholars closely coincide and co-authorship and co-research is mutually beneficial. Topics to be included herein should encompass fundamental methodology; application of computer and modeling techniques; construction of models; and computing methods, algorithms, and programs.

5. Joint development of courses and colloquia at advanced levels in computer and research techniques in this field with each country supplying approximately equal amounts of faculty and other requisite resources.

6. Organization of special-purpose conferences, symposia, and seminars for discussing research results and the state-of-the-art in this field.

A proposal was submitted to the National Science Foundation for support of this program and was approved during March 1974; Gary Fromm, Harvey J. McMains, and John R. Meyer are the co-principal investigators under this grant.

More than 100 leading U.S. scholars whose research and work are in or related to the topics of cooperation have been contacted and invited to participate in the program. Their response has been enthusiastic and, with few exceptions, all have provided lists of publications, vitae, reprints, reports, and other materials for use in the exchange-of-information phase. Selections from these and abstracts on approximately 600 re-

search projects have been transmitted to the U.S.S.R.

A planning committee is being formed to meet with Soviet scholars to arrange the exchange visits by both sides and participation in scientific meetings. It is anticipated that Soviet scientists will participate in seminars of the NBER–NSF Conference on Econometrics and Mathematical Economics that are held periodically throughout the academic year at various universities and research centers, in joint American Economic Association–Econometric Society sessions at winter 1974 meetings in San Francisco, and in the 1975 World Congress of the Econometric Society to be held in Toronto, Canada. Also, it has been proposed that an initial conference might be held in the U.S.S.R. late in 1974 or early in 1975 on the topic of Models and Economic Policy Planning and Programming.

It is hoped that this and other conferences, exchanges of information, and visits by U.S.–U.S.S.R. scholars and the programs of research, some of it joint, will further the scientific state-of-the-art in both countries and lead to greater mutual understanding and cooperation. As such, it should lead to easing of international tensions and contribute to the cause of world peace.

Gary Fromm

Studies of Multinational Firms

The studies described below are a set of inter-related projects drawing on an entensive data base relating to multinational firms that the Bureau has been assembling. The data base consists of the various reports on individual U.S. parent companies and their foreign affiliates collected by the Bureau of Economic Analysis of the U.S. Department of Commerce, combined with a variety of information on individual companies collected by the National Bureau. All computations on the combined data must be done within the Department of Commerce, but we have been able to use the results of these computations in several studies. We plan to add to the data base over the next several years as we conduct substantive studies, and we expect that its value will continue to grow as the data accumulate.

The data base began as part of the study of The Relation of U.S. Manufacturing Abroad to U.S. Exports, financed mainly by grants from the National Science Foundation and the Ford Foundation, continued under a later grant from the Ford Foundation for a study of The Effects of Direct Investment on Recipient Countries, and is now being extended in the course of a new study on The Impact of Multinational Firms on Technology and Trade Flows, supported by the National Science Foundation. As a first step, data from the Office of Business Economics surveys of U.S. investors covering the period 1962–65 were linked with the National Bureau's financial data for the same firms and certain data collected by the Office of Foreign Direct Investments. These data were then supplemented by information on the number, age, location, and activities of U.S.-owned affiliates abroad, acquired through a Bureau questionnaire addressed to several hundred companies, and by Dun and Bradstreet data on the industrial distribution of the domestic activities of U.S. firms. Recently we have expanded our collection of domestic data to cover a much larger number of firms and linked these data to the 1966 and 1970 direct investment censuses of the Bureau of Economic Analysis. Also as part of our latest study we hope to add information on the composition of the labor force, by broad occupational groups and some demographic characteristics, for individual firms.

A new study of financial aspects of multinational firms has been started by Professor Rita Rodriguez of the Harvard Business School. That study, based on data she has collected on foreign currency operations of a sample of large firms, will investigate two topics. One is the financing of overseas affiliates, particularly the response of such financing to interest rates, currency fluctuations, and related variables. The second is the extent to which multinational firms' financial operations support or thwart the monetary and fiscal policy objectives of host-country governments, and the extent to which the operations of these firms differ in this respect from those of native or other foreign-owned companies.

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

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

Our main efforts this year have been in two directions: One is a fairly intensive examination, using a cross-section of importing countries, of investment and trade in the pharmaceutical industry, which we hope can be a prototype for analysis of other industries. The second is an analysis of interrelations, in a cross-section of U.S. firms, among their size, the amount of their overseas activity, and their exports from the United States. This analysis has been extended in the last few months to the 1970 data collected by the Bureau of Economic Analysis of the U.S. Department of Commerce, and the next step will be to examine the more comprehensive 1966 data.

The analysis of the pharmaceutical industry so far suggests that there are substantial differences in the relationship of exports to the activity of U.S.-owned foreign affiliates as between developed and less-developed countries. However, one consistent result appears to be that the presence of U.S. affiliates in an area tends to reduce exports to that area by countries other than the United States, whereas the presence of affiliates of foreign countries tends to reduce U.S. exports.

In addition to the three papers published so far[1] we have prepared a revised and improved analysis of transport charges, which appeared in the first issue of *Explorations in Economic Research,* and a working paper on "Multinational Firms and the Factor Intensity of Trade," which we have circulated for comment.

<div align="right">Robert E. Lipsey
Merle Yahr Weiss</div>

[1] Robert E. Lipsey and Merle Yahr Weiss: "The Relation of U.S. Manufacturing Abroad to U.S. Exports: A Framework for Analysis," *1969 Business and Economic Statistics Section Proceedings, American Statistical Association,* pp. 497–509; "Estimating the Structure of International Transport Costs," *1971 Business and Economic Statistics Section Proceedings, American Statistical Association,* pp. 418–424; "Analyzing Direct Investment and Trade at the Company Level," *1972 Business and Economic Statistics Section Proceedings, American Statistical Association,* pp. 11–20.

The Impact of Multinational Firms on Technology and Trade Flows

The purpose of this study, financed by the National Science Foundation, is to examine the nature, extent, and effects of technology transfer by and through multinational firms. We are asking whether the current comparative advantage of U.S. firms is based on their technological abilities, whether these firms carry their technology with them when they operate abroad, and how any transfers of technology via such operations affect international comparative advantage and the flow of trade. Among the specific questions to be asked are:

1. What determines a firm's share of foreign markets and its choice among exports, licensing, and overseas production as ways of supplying that share?

2. What effect do these choices have on the location of production and the composition and level of U.S. exports and imports?

3. To what extent do U.S. firms, when they do manufacture abroad, transfer the technology used in the United States to their foreign operations? How much do they adapt their technology to local conditions?

In addition to the basic data collection, described above, and the statistical analysis, several case studies will examine individual countries or areas. Benjamin Cohen of Yale University, and Jorge Katz, now at the Instituto DiTella in Argentina, are studying the pharmaceutical industry. With the aid of a consultant in pharmacology, they are compiling lists of innovations in the industry, categorizing them according to both originality and importance, and associating them with particular companies. They plan to trace the influence of research and development effort and innovation on firms' policies with respect to foreign investment, licensing, and exports, and then examine the effect these policies have on the rate of geographical spread of innovations and on trade in pharmaceuticals.

A second case study, which is being conducted by William Finan of the Wharton School, University of Pennsylvania, is an examination of the semiconductor industry. Mr. Finan has already made a large number of contacts in the industry, conducted several interviews with companies, and extended the tabulation of innovations and their timing from an earlier study of this industry.

A third case study, on the introduction of innovations into the United Kingdom, has been undertaken by Arthur Lake of Cambridge University under the supervision of Gary Hufbauer. Mr. Lake has tentatively selected eight industries for which he will attempt to develop lists of product and process innovations, dates of introduction, and the channels by which they were introduced. He will be distinguishing U.S.-owned firms, British licensees of U.S. firms, and other British firms, and examining not only the initial introduction of innovations but also their adoption by imitators.

Robert E. Lipsey
Irving B. Kravis

The Role of Prices in International Trade

In the last year we have completed the construction of several sets of new price indexes for the analysis of changes in trade flows. In addition to the indexes for two-digit SITC classes, we have now compiled price indexes for the most detailed trade groupings available, usually three- or four-digit SITC groups and subgroups, and will complete the calculation of price competitiveness and quantity indexes within the next few months. We have also calculated indexes for some separate destinations, including as destinations several regions of the world and each of the exporting countries we study: the United States, the United Kingdom, Germany, and Japan. The indexes are international price and price competitiveness indexes, interpolated and extrapolated from those published in *Price Competitiveness in World Trade,* export price indexes for Germany and Japan, and domestic price indexes for each country, weighted in the same way as the international price indexes. We plan to use the trade-weighted domestic price indexes to examine the effects on exports of changes in the relation of export to domestic prices. For Germany, we will supplement our analysis of annual data by using a set of monthly indexes calculated in the same way and carried forward to the most recent period available.

A paper on "International Trade Prices and Price Proxies," comparing several measures of prices used in analyzing international trade, appears in the recent NBER volume on *The Role of the Computer in Economic and Social Research in Latin America,* edited by Nancy Ruggles.

The studies on international price measurement and the role of prices in trade have been supported by grants from the National Science Foundation. Marianne Rey has been responsible for price collection and computer programming during the past year.

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Irving B. Kravis
Robert E. Lipsey

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Foreign Trade Regimes and Economic Development

Six of the ten country studies in this project are now in press or soon will be. These are the studies on Turkey by Anne Krueger, on Ghana by Clark Leith, on Israel by Michael Michaely, on Egypt by Bent Hansen and Karim Nashashibi, on the Philippines by Robert Baldwin, and on India by Jagdish Bhagwati and T. N. Srinivasan. The other country studies are nearing completion. A sizable portion of our total effort has been devoted to the preparation, review, and mutual criticism of the individual studies.

Research for the lessons emerging from the studies is now under way as results from individual studies become final. There are three main areas in which we are attempting to analyze the individual countries' experiences on a common basis. The first relates to the nature of the payments regime and the way it changes over time. Naturally, every payments regime has to be analyzed in the context of the domestic economy, but we can identify certain common factors leading to proliferation of increasingly complex exchange control regulation, once started, and also certain self-perpetuating factors in liberalized trade regimes.

The second major area of analysis relates to the experience with exchange-rate alterations and easing of controls. Here, again, individual differences in exchange regimes and domestic policies must be taken into account, and the appropriate questions center on an analysis of *effective* exchange-rate changes by individual commodity classes. Considering changes in quantitative restrictions, special tax and subsidy arrangements, and other features of the foreign trade system, effective devaluation is usually much smaller than would be implied by the changes in the official rates alone. Some general tendencies emerge from comparison of individual country episodes but overall it appears that specific disturbances—crop failure, inflation rates, political stability or its absence—are also significant in determining the success and durability of efforts to liberalize the trade regime.

The final question is the relationship between the nature of the trade regime and economic growth. Again certain general tendencies and conclusions are emerging from the results of the individual studies as the research continues.

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Jagdish N. Bhagwati
Anne O. Krueger

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6. MEASUREMENT METHODS AND OPERATIONS

Research on Computer-Based Quantitative Methods

Introduction

The NBER Computer Research Center for Economics and Management Science completed its third year in January 1974. Major developments during the past year, for the most part foreshadowed in last year's progress report, include an expansion of collaborative research through a nationwide data-communication network, availability of a new linear programming system called SESAME, launching of a major research effort on robust and ridge regression, and further progress on simultaneous equation estimation and the estimation of time-varying parameters. Further details of these and other developments appear in subsequent sections.

The evolution of the Center into a truly national facility was expedited when, in August 1973, the

Center's principal computer (located in New Haven) was linked to a nationwide data-communication network with local outlets in over thirty cities. Active use of Center software by researchers at Cornell, Carnegie-Mellon, the University of Wisconsin, Milwaukee, the University of Chicago, and the University of California, Berkeley, has already started. We anticipate that another ten to twelve universities will join in the Center's research activities or use the Center's software during the coming year. Although the network is one principal enabling condition, another is an efficient software environment, developed by Center programmers and researchers, and buttressed by good documentation. At the present time, one large system for linear programming, SESAME, is ready for release to the experimental community. This system will be elaborated, shaken down, and revised, together with its documentation, for release to the entire user community toward the end of the year. A similar cycle is underway in the areas of econometrics and data analysis, for which over a dozen small software systems have been designed in the TROLL environment and have been, or soon will be, released as TROLL Experimental Programs. If a system is considered to be of sufficiently widespread interest, it will be refined, together with its documentation, and released to the research community after user criticism is obtained.

Research activities at the Center are intended, first, to provide improved basic algorithms and much more accessible software that will be of interest to a significant segment of the economics or management science communities. Second, experimental software is created to facilitate collaborative research throughout the United States. Third, finished systems that evolve from on site and collaborative research are made available to the general user community.

The first objective, as the following research reports indicate, has been well met, and interaction among the different research activities has also been significant. Last year new software systems were developed that provided the foundation for several collaborative research projects already in hand, and at least a half-dozen more are expected to start during the current year, so that the second goal is well advanced.

The final objective, dissemination to the entire research community, will accelerate toward the end of 1975. By that time, the Center plans to convert all its programs to run on suitable IBM 370 computers; the latter are much more widely available than the IBM 360/67 (which, however, will continue to run some systems on the network). At some point early in 1976, all programming will be transferred to an IBM 370 computer, and contact with research collaborators will be continued through the data-communication network. In addition, many algorithmic subroutines are programmed in FORTRAN and, with a modest additional effort, can be run on a wide variety of computers.

Edwin Kuh

Mathematical Programming

In the past year the Center's most important accomplishment in mathematical programming was the completion of the SESAME system for linear programming and its extensions. SESAME was built by William Orchard-Hays, Michael Harrison, and William Northup. It can solve general linear programming problems with 2,000 or more rows and over 10,000 variables. For linear programming models with structures that occur in transportation and scheduling optimization, SESAME can solve problems with up to 50,000 constraints and an almost unlimited number of variables. SESAME includes an interactive capability for linear programming sensitivity analysis. A language for generating linear programming models from basic data and logical relations is under development and should be completed this year. A workshop in mathematical programming centered about the SESAME system was held at the Center on March 28–29, 1974, and was attended by mathematical programming researchers and practitioners from universities, government agencies, and industry throughout the U.S.

Experiments with dual methods of integer programming and other combinatorial optimization models were recently completed by Marshall Fisher, William Northup, and Jeremy Shapiro. They presented a paper on their work at the Mathematical Programming Symposium at Stanford University in August 1973. Dual integer programming methods will be among the inno-

vative features of the large mixed integer programming system now under development at the Center. This system will also make heavy use of SESAME to solve linear programming approximations of integer programming problems.

Another area of progress has been the development of programs to compute economic equilibria by fixed point approximation. The programs are being constructed by Odunayo Olagundoye; they are being applied to equilibrium analyses of urban housing markets by Jeremy Shapiro and Joseph Ferreira of the Urban Studies and Planning Department at MIT. Marshall Fisher and F. J. Gould of the University of Chicago are collaborating with the Center in using these methods to solve nonlinear programming problems. Herbert Scarf of Yale University, the originator of the fixed point approximation methods, is a consultant to the Center.

The staff is also applying the Center's new systems to various mathematical programming problems. These include supply, demand, and distribution studies of the U.S. natural gas pipeline system; stochastic programming models for water-resource planning; and refinery-location models for a long-range world-petroleum model.

Jeremy Shapiro

Data Analysis

Over the past year the Center's Data Analysis Project has progressed toward making interactive data analysis possible through the Center's computer facilities and the network. This progress includes both research on, and the implementation of, new data analytic methods.

Robust and Ridge Regression

A major interest has been robust regression—i.e., regression methods that are not sensitive to a few wild values or to small changes in the model or the data. In June 1973, David Hoaglin organized a two-day working conference on robust regression, bringing together about twenty statisticians and economists who have contributed to this growing field. This conference, held at the Center, led to a lively exchange of ideas and has provided feedback on our own plans for a Monte Carlo study of robust regression methods.

We have carried out the first stage of this Monte Carlo study. The well-known method of minimizing the sum of absolute residuals—"least absolute residuals" (LAR)—served as a starting point, and various methods for improving this start have been examined. We have found that a single weighted least squares iteration, with weights based on the LAR residuals, provides a significant improvement on LAR in both Gaussian and non-Gaussian cases. We are currently studying the role of the data matrix in these methods, as well as methods for setting confidence intervals for the regression parameters. Principal researchers on this part of the project, in addition to myself, are Richard Hill, David Hoaglin, and Roy Welsch.

David Hoaglin has continued his research on asymptotic variances of location-parameter estimates. This work is fundamental to the study of regression problems in that it provides a base line for multivariate problems and suggests new methods in a simple context in which it is easier to see what is going on. Our Monte Carlo work has also led us to study random number generators and their properties.

Using tools developed for the Monte Carlo study, Richard Becker of the Center's programming staff put together a TROLL macro that allows the user to apply various robust regression methods to his data. The user can do LAR regression and the iteratively reweighted least squares improvements on it that have been suggested by Huber, Andrews, and Tukey. In addition he can obtain a plot, called a "Huber trace," that graphs the values of the regression coefficients as a function of a robustness parameter.

Ridge regression has attracted more and more interest over the past year, and at the Center we, too, have been studying it. This Bayesian method offers a significant improvement in the estimation of regression coefficients if the data matrix suffers from near collinearity and many parameters are involved. Using sophisticated numerical methods suggested by the Center's numerical analyst, Virginia Klema, Richard Becker created a TROLL macro that provides the user with a flexible system for performing ridge regression. The user of this macro can obtain various empirical Bayes choices of the ridge parameter, input a nonzero prior mean for the regression coefficients, and obtain a plot, called

a "ridge trace," which graphs the estimated regression coefficients as a function of the ridge parameter. The user may even supply weights computed from robust regression and thus combine the robust and ridge regression methods.

Log-Linear Models

The analysis of discrete data has been receiving close attention from Center researchers. By using the equation-solving capability in TROLL, I have found it easy to fit Poisson regression models to data by maximum likelihood. I used this technique experimentally. with economic data on the generation of new products, and more seriously in collaboration with a sociologist, Samuel Leinhardt, for a model of the distribution of doctors in Pittsburgh. In addition, we have implemented three TROLL functions that will allow the user to fit log-linear models to multidimensional contingency tables and to solve the inverse problem of adjusting a given data table to prescribed margins. Both of these tools will allow users with cross-sectional data to apply these new methods to their problems. Roy Welsch and I will be using these tools in a reanalysis of some medical data on heart disease in association with the Harvard Faculty Seminar on Human Experimentation in Health and Medicine.

Graphical Techniques

One of the most exciting developments for data analysis is computer graphics using inexpensive terminals like the Tektronix 4010. Under the guidance of Roy Welsch, new graphics subsystems have been implemented by Helge Bjaaland and installed in the TROLL system. A basic one, CLOUDS, allows the user to rotate a multidimensional point cloud in any direction and then project it back on any two-dimensional set of axes. Besides making fast scatter plots easy, this technology allows the user to look for multidimensional outliers and important structural features in his data. This program has provided the basis for a number of other plotting facilities, including Tukey's "schematic plots" and plots of two-way fits for exploratory data analysis; the ridge trace plot in the ridge regression macro; and the Huber trace in the robust regression macro. All of these graphical tools can provide

the user with extra insight into his data. Residual analysis is made easy using CLOUDS, and a macro called NORMPLOT may be used to obtain normal probability plots of residuals.

Stimulated by the work on robust regression, data analysis, and graphics, the Center has begun to develop cluster-analysis methods and to make them available to users. Donald Oliver, a new member of the data-analysis research group, is putting a hierarchical clustering program into TROLL and is active in the development of new clustering methods. Two graphical methods for clustering multivariate data have been implemented. Chernoff's Faces method, which represents each multivariate data point as a schematic human face, provides a novel and useful way to cluster data. The Star plot, which represents each point as a polygon, is also available and is another potentially useful clustering procedure.

We continue putting exploratory data-analytic tools into TROLL. Recent additions include a good version of Tukey's resistant line, and DIPLOT, which gives a diagnostic plot for a two-way table that reveals whether or not some of the interaction is removable by a power transformation.

I have established a collaborative research project with two sociologists, Samuel Leinhardt at Carnegie-Mellon and James Davis at the University of Chicago and National Opinion Research Center. We are developing new methods for the analysis of small-group social structure. Our work will provide new methods for analyzing sociometric data and will eventually allow the social scientist to specify and test structural hypotheses and models in a simple way via the computer network.

Paul W. Holland

Simultaneous-Equation Systems

Major efforts of the Center's econometrics group have been devoted to designing and developing a comprehensive system of simultaneous-equation estimators called GREMLIN. Progress on GREMLIN has been made in three areas: (1) completion of a detailed design document, (2) a planning conference (held in November 1973) of leading scholars in the field, and (3) the implementation of the system.

The Design Document

David Belsley's draft design specifications of GREMLIN were included in the Center's last progress report (October 1973) to the National Science Foundation. Revised design specifications will be published in the October 1974 issue (Vol. 3, No. 4) of the NBER's *Annals of Economic and Social Measurement*. These specifications will serve as the basis for programming the following estimators:

Double k-class (two-stage least-squares, limited information maximum likelihood, and unbiased k to order T^{-1}), linear and nonlinear in the parameters.

Three-stage least-squares (3SLS), linear.

Instrumental variables (IV):

    1. Single-equation, linear and nonlinear.

    2. Simultaneous-equation (LIVE and FIVE), linear.

The design of GREMLIN includes computational algorithms that have recently been developed by numerical analysts and that make many standard econometric calculations significantly more stable and efficient. These numerical techniques are described and applied in numerous circumstances in the GREMLIN design specifications and hopefully will be of general interest to the econometrics profession. Virginia Klema at the Center and Gene Golub, Stanford University, have provided useful guidance in the field of numerical methods.

The October 1974 issue of the *Annals* is to be devoted entirely to the subject of estimation of simultaneous systems. In addition to Belsley's GREMLIN specifications, this issue will contain papers co-authored by Ernst Brendt (University of British Columbia), Bronwyn Hall (Harvard), Robert Hall (MIT), and Jerry Hausman (MIT); by James Brundy (San Francisco Federal Reserve Bank) and Dale Jorgenson (Harvard); and by Jorgenson and Jean-Jaques Laffont (University of Montreal); as well as individual contributions by Ray Fair (Princeton) and Hausman. Hausman's paper offers theoretical justification for applying the FIVE estimator iteratively to obtain full information maximum likelihood (FIML) estimates of a linear system; this facility will become a part of GREMLIN. Jorgenson and Laffont provide a means for obtaining nonlinear three-stage least squares estimates; this will also be incorporated into GREMLIN. The issue is being edited by John Kirsch of the Center's support staff.

The Planning Conference

In November 1973 the Center sponsored a planning conference on simultaneous equation-system estimation. Leading researchers from other institutions joined members of the Center's staff in discussing problems and establishing research priorities. Participants included Takeshi Amemiya (Stanford University), T. W. Anderson (Stanford University), John Cragg (University of British Columbia), Dale W. Jorgenson, and J. Kadane (Carnegie-Mellon University). Representing the Center were David Belsley (Boston College), Mark Eisner, Richard Hill, and Edwin Kuh (MIT).

Particular attention was paid to assessing the then-tentative plans for GREMLIN. It was generally agreed that the planned scope of the system was proper but that delays might result from attempting to produce at the outset a computationally efficient system for use in Monte Carlo experimentation. Such delays, it was felt, would not be warranted; rather, it would be better to make a usable system available as soon as possible and work toward computational efficiency in subsequent refinements.

Implementation

Programming of GREMLIN, as specified in the design document, is now under way. Utility modules to be used by all of the estimators, and the modules for the k-class estimators, have been coded and are being debugged. The IV estimators will be coded next; then 3SLS and FIVE; and finally nonlinear FIML. Subsequent refinements will reduce computational costs and result in a system that is suited for efficient Monte Carlo experimentation.

David A. Belsley

Spectral Analysis and Spectral Regression

Introduction

The Center has developed and tested spectral analysis and spectral regression programs with

a view toward important empirical application. The software development is intimately connected with a series of empirical research projects designed either to test the estimators or to use the procedures in relevant investigations.

In summary, the software development is now complete. Monte Carlo studies indicate that the small-sample properties of these estimators are better than anticipated, and applications of these techniques to estimation of investment and consumption functions confirm the promise of spectral methods in economics.

Programs

The programs are a set of functions that, in combination, compute spectral and cross-spectral estimates. When combined with a regression procedure, they compute efficient estimates of a linear regression with serial correlation (the Hannan estimator), distributed lag estimates, or band spectrum regressions. These functions are all called by master macros complete with defaults so that the user need know nothing about spectral analysis in order to obtain the analysis. Yet the function routines are flexible so that a sophisticated user can generate his own techniques.

The user interface as well as the component parts are described in two manuals now available. These manuals contain a detailed introduction to the interpretation and understanding of the tools. Coupled with the manuals is a more advanced paper by Engle (4)[1] describing the relation between spectral methods and time-domain methods (distributed lag and Box-Jenkins procedures) as well as the justification for the procedures used in the spectral computations. Nevertheless, the paper can be read by a user who has no prior knowledge of spectral analysis. A paper on band spectrum regression by Engle (3) establishes the basic results and algorithms for the spectral regression package.

Testing Estimators

The desirability of correcting for serial correlation in a linear regression in order to obtain efficient estimates is widely recognized. When a specific form for this serial correlation is not

known, the principal estimator that can guarantee asymptotic efficiency is a spectral estimator, originally proposed by Hannan. However, it is rarely used, partly because the programming is difficult and partly because its finite sample behavior is presumed to be far worse than asymptotic behavior.

Because this estimator is desirable theoretically, it was included in the spectral package. In order to examine the finite sample properties of the estimator, Roy E. Gardner (Cornell University) and I performed an extensive Monte Carlo test in a variety of economically relevant environments.

The conclusions described by Engle and Gardner (6) indicate that if serial correlation is of a relatively simple form, then the Hannan estimator reaches its asymptotic efficiency for samples of size 50 or more. If serial correlation is more complicated, the Hannan estimator has roughly twice its asymptotic variance at a sample of size 100. In all cases, the spectral estimators appeared to be unbiased for sample sizes over 50. There are many qualifications to these results described in the original paper but the conclusions are clear: for economically relevant sample sizes (U.S. post-World War II quarterly or monthly data) these estimators perform well.

Economic Applications

In a paper on band spectrum regression (3), I describe sensible economic applications of spectral analysis to problems of estimating regressions subject to seasonality, errors in variables, or misspecification in different frequency bands. A test statistic is derived for testing the hypothesis that the regression coefficients are not stable across frequency bands.

Also in this paper, I examine an application to the estimation of consumption functions. If the permanent income hypothesis is valid in its simplest form, then the marginal propensity to consume out of transitory income should be smaller than out of permanent income. Identifying the high-frequency components as transitory income, we should reject the hypothesis that the regression coefficients are the same at different frequencies. In fact, we are not able to reject this hypothesis and thus, at least in this simple model, the permanent income hypothesis re-

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[1] Works cited by author and number are listed in the bibliography (pp. 112–113).

ceives no support.

In a second application of these techniques, Duncan K. Foley and Engle (5) estimated an investment function that was derived from a theory of macroeconomic behavior based on supply limitations. The data, however, suffered from errors of observation that were assumed to lie within particular frequency bands. We had remarkable success in estimating the model using band spectrum regression, which suggests the usefulness of spectral techniques for macroeconomic applications.

A third application of the spectral package began early this year and is expected to be completed soon. In the formulation of distributed lag models it is generally assumed that the same lag distribution applies at all frequencies. Using the technique of band spectrum regression, this assumption can be tested. A model of price formation before the 1971 "price freeze" is used to test this assumption about the structure of expectation. Preliminary results by Kenneth Wise and me indicate substantial deviations in the responses to seasonal and nonseasonal changes in input prices. These results should aid in understanding the dynamics of inflation and, in particular, shed light on the accelerationist controversy.

Robert F. Engle

Estimation Methods for Time-Varying Parameters

Changing or random parameters occur in virtually every area of econometrics. In cross-sectional time-series data, for instance, the behavior of an individual in the cross-section should often be assumed different from others. This assumption leads to Rosenberg's random parameter formulation (8). In last year's *Annual Report*, the Center's first efforts in this area were described. Late in 1973, a group based at the Center was organized to explore and implement estimation methods for models with changing parameters. This group is composed of Tom Cooley (Tufts), Swarnjit Arora (University of Wisconsin, Milwaukee), Barr Rosenberg (University of California, Berkeley), David Belsley (Boston College), and Aleco Sarris (MIT).

During a two-week working meeting of the group in August 1973, it was decided to initiate a simulation study of the methods that are presently available, the objective being to assess their performance under a wide variety of conditions encountered in econometric research. The methods to be studied are those of Rosenberg (8), Cooley and Prescott (2), and Sarris (9). The programming has been and will continue to be collaborative. Programs written independently by Rosenberg and Cooley will be used with optimization packages that are being developed at the Center.

The aim is to evaluate existing estimation methods, to develop new ones, and to program (within about a year) a user-oriented interactive computer package that includes the best methods.

The October 1973 issue of the *Annals of Economic and Social Measurement* was devoted to papers on estimation methods for time-varying and stochastic parameters.

Aleco Sarris

Numerical Analysis

The focus of work in numerical analysis at the Center for the past year has been the development and use of robust programs for numerical mathematics; these programs are needed in several of the application subsystems being developed by other Center projects. We have used existing software from EISPACK, Edition II, for the calculation of eigensystems, and certain subroutines from the Argonne National Laboratory's subroutine library for the generalized eigenproblem and singular value decomposition. The modularity of the Center's application subsystems facilitates the insertion of these and other numerical programs and, further, provides a convenient test bed for algorithmic software development.

Recent programming by Richard Becker has shown the Center's capacity to use existing software, augmenting it when necessary, to develop a new program for the optimization of an objective function. John Dennis (Cornell University), a specialist in optimization theory who serves as a consultant to the Center, suggested that we use a variant of one of Powell's algorithms. This algorithm combines the conjugate gradient method with Newton's method; however, it did not take advantage of analytic derivatives, and

it did not monitor the presence of positive definiteness of the second derivative matrix in iterations tending toward the solution. Two subroutines from EISPACK make available the positive definite matrix approximation, and the Center's analytic differentiation routine supplies analytic derivatives. The conjugate gradient and Newton steps were programmed in this framework from first principles described by Dennis.

Another new algorithm developed at the Center by Richard Hill is least squares with equality constraints that uses two sets of results from a singular value decomposition program written at the Argonne National Laboratory. This subroutine was augmented by Richard Becker and Fred Ciaramaglia to produce the best approximate solution for a linear system of equations whose matrix of coefficients is rank deficient.

Extensive work has been carried out at the Center to demonstrate the strengths and occasional weaknesses of various numerical algorithms used. The algorithms are numerically stable in that the solution obtained is the exact solution of a neighboring problem. We have monitored the sensitivity of the solution to perturbations (i.e., slight changes) in the input data, and can prescribe limits for these results. We can isolate dependencies among variables or among equations within systems of equations. If problems involving linear (or, to a lesser extent, nonlinear) systems of equations are involved such that their solution is likely to be of little significance, we can expose the structure of the problem so that the user or the problem originator can pose the problem in a way that is more amenable to solution. Neil Kaden has done the programming for this software validation.

We have relied heavily on the advice of Gene Golub (Stanford University) in the design and statistical interpretation of results from two-stage and three-stage least squares and k-class estimation. Golub's continuing collaboration assures a nonlinear estimation capability that will be viable from the standpoint of statistics and numerical mathematics. Enhanced performance can be expected from appropriate attention to equilibration, again with Golub's collaboration.

Given our interdisciplinary approach, we hope to improve interpretations of singular value analysis. We also plan to explore and develop the use of the orthogonal basis of invariant subspaces. As this work proceeds, we expect to keep in touch with J. H. Wilkinson and with Golub.

<div align="right">Virginia Klema</div>

Computer Programming

The Center's Programming Staff has continued to provide support for the ongoing research effort and at the same time has been developing system software for future research. Under the overall direction of Gerald Ruderman, the staff has adopted new computer-science methodology, including structured programming and top-down design. This formalized approach to software development not only has improved the quality of the Center's programs but also will facilitate their maintenance.

Application Programming

Ongoing application research is being supported by the Mathematical Programming and Statistical Application Groups. The Mathematical Programming Group, under the guidance of William Orchard-Hays, has provided the fundamental component of a mathematical programming laboratory with the completion of SESAME. Michael Harrison continues to work on the development and enhancement of the linear programming capability, and William Northup has begun development of a research system to solve integer and mixed integer problems.

The Statistical Application Group (STAG), working closely with the various research projects in statistics and econometrics, has developed many experimental application systems. These experimental systems are produced primarily by Richard Hill and Richard Becker and run within the TROLL environment. An interactive graphics capability, originally developed by Helge Bjaaland, is now being maintained and enhanced by David Rice. As these systems are completed, documentation appears in the manual *TROLL Experimental Programs*. In addition, STAG continues to provide programming support and internal experimental systems for research in statistics and econometrics.

System Programming

The other active area of program development

<div align="center">110</div>

is basic system-software tools. These tools will enable future researchers to develop efficient interactive application programs with a minimum of effort. The two large projects undertaken in this area are ACOS/ACOL and DASEL.

ACOS/ACOL is a specialized Application Control System and Language that will provide the operating environment for all future application systems built at the Center. Annette Somers, David Rice, and David Boyajian have completed the external and internal design specifications for ACOL, and expect to have a first version running by the end of the year. Walt Oney and Dave Anderson have been working on the internals of ACOS such as the file system, I/O switch, and operating system interface. The Center expects that ACOL/ACOS will not only benefit work at the Center but will also introduce a useful concept to·the general computer-science community.

The second large system project is the creation of DASEL, a new programming language for social-science and statistical algorithmic development. DASEL has emerged from our own experience with TROLL and from the experience of many others with APL. It has many innovative features such as symbolic differentiation and an n-way array manipulator. The design work, which is now completed, was done primarily by Joan Zahorjan with the assistance of Fred Ciaramaglia and Richard Hill. A draft design specification of the language is now available. A final version of DASEL should be available by the end of 1974.

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

Documentation

The main effort of the Support Staff during the past year has been in documenting the new major systems being developed by the Center— ACOS, DASEL, and SESAME—and the new group of small systems called TROLL Experimental Programs. Additional documentation for the basic TROLL facility was also compiled for both users and programmers.

Much of the research described in the preceding sections of this report has resulted in new subsystems that operate within TROLL. In January 1974, documentation of these subsystems began to appear in a serial publication entitled

TROLL Experimental Programs (TEP). The installments of *TEP* that have been published to date, and the subsystems that they describe, are as follows:

Miscellaneous Data-Analysis Tools: Subsystem for statistical and graphical summaries of data, and for resistant analysis of data, along lines suggested by J. W. Tukey (10).

Probability Distributions: Subsystem for cumulative distribution functions of various probability distributions, and for pseudo-random samples from populations having various distributions.

CLOUDS: Subsystem for graphically displaying and analyzing multivariate data as "clouds" of points in an n-dimensional space.

FACES: Subsystem for graphically displaying multivariate data as cartoon-like faces (implementing an idea of H. Chernoff (1)).

STARS: Subsystem for displaying multivariate data in circular graphs known as star plots.

Robust and Ridge Regression: Subsystems for regression analysis in the presence of contaminated data, outliers, and multicolinearity.

Spectral and Cross-Spectral Analysis: Subsystem for estimating the spectrum of one time series and the cross-spectrum of two series.

Spectral Regression: Subsystem for band spectrum regression and for estimation in the presence of serial correlation.

Log-Linear Models: Subsystem for fitting log-linear models to multidimensional contingency tables and for adjusting a given data table to have prescribed margins.

Numerical Methods: Subsystems for computing the singular value decomposition of a matrix (Golub and Reinsch (7)), and for other sophisticated algorithms of numerical algebra.

Matrix Manipulation: Subsystem for a wide range of computational, retrieval, and editing operations on two-dimensional matrices.

Matrix Labels (LEDIT): Utility subsystem for naming the columns and rows of matrices (used in retrieval and printing).

A preliminary *ACOS Overview* was developed late last year, and work has started on an *ACOL Language Manual* and an *ACOS System Manual.* The latter two documents are a collaborative effort between the Support Staff and the Programming Staff. Support for DASEL was provided

through participation in the planning and writing of the system's external language specifications. SESAME was also a collaborative effort, in this case with the Mathematical Programming Group, resulting in preliminary editions of the following manuals:

SESAME: Design and Capabilities Overview

SESAME Primer

SESAME Reference Manual

SESAME Reference Manual, Supplement 1: DATAMAT

During the past year, three-quarters of the comprehensive *TROLL Reference Manual* was written and published, with the rest to come this year. Also published during the past year were the *TROLL Primer: Cross-Sectional Data Supplement* and the *TROLL Programmer's Notebook,* a collaborative effort with the Programming Staff. For internal use, forms were developed for reporting software problems, writing design specifications, and writing usage specifications.

The documentation listed above was written by Robert Perron, Gary Solomon, Wayne Zafft, and me, with help and guidance from the Programming and Research Staffs. Joe Glendenning and Sheila Howard handle editing and production. Robert Fourer joined the Support Staff in June 1974 and assumed principal responsibility for documentation of the mathematical programming systems.

John Kirsch

Computer Operations Activity

In 1973 the NBER Computer Operations Activity (COA) was established to manage the Bureau's rapidly growing computer and data-communication requirements and to oversee the dissemination of TROLL and other NBER software. The COA functions for the Bureau in much the same way that a standard computer center functions for a university.

The COA, with a staff in New Haven, New York, and Cambridge, helps coordinate the computer requirements of the various offices and assists the research staff with the technical and administrative problems they encounter in using the computers. The staff includes Walt Maling, TROLL user consultant (Cambridge);

Gerald Ronkin, Tom Eaton, and Warren Lackstrom, the administrative staff (Cambridge); and Dave Anderson (Cambridge); Jane Carrol (New Haven); Andrea Collins (Cambridge); Terry Echaniz (New York); Orin Hansen (New Haven); and Martha Lichtenstein (New York).

All computer time, equipment and supplies, data-communication facilities, and personnel costs are purchased by and charged to the COA. The COA has established standard rates and sees that all costs are properly allocated to both NBER and ouside users. A major activity of the COA this year was to link the Yale computers (both the IBM 360/67 and the IBM 370/158) with a national data-communication network. Using this network, researchers in about forty major cities throughout the United States can —for the cost of a local telephone call—gain access by telephone to the Bureau's programs on the Yale computer.

The TROLL system is currently maintained on the Yale 360/67 and is accessible via the network. Academic and other nonprofit institutions, as well as governmental agencies, may purchase computer time to use TROLL. Communities of researchers who are actively using TROLL are in Boston, New Haven, New York, Washington, D.C., Pittsburgh, Cleveland, Chicago, Milwaukee, Palo Alto, San Francisco, and Louisville.

The COA is administering the computing requirements of collaborative research projects organized through the NBER Computer Research Center. Through the network, researchers throughout the country are provided access to the software developed by the Center and maintained by the COA at Yale.

Gerald Ronkin
Walt Maling

Bibliography

1. H. Chernoff, "The Use of Faces to Represent Points in *k*-Dimensional Space Graphically," *JASA,* Vol. 68, June 1963.

2. T. F. Cooley, and E. Prescott, "Varying Parameter Regression: A Theory and Source Applications," *Annals of Economic and Social Measurement,* Vol. 2, No. 4, October 1973.

3. Robert F. Engle, "Band Spectrum Regression," *International Economic Review,* 1974.

4. Robert F. Engle, "An Introduction to the Spectral Analysis Capability," *International Economic Review*, 1974.

5. ———, and Duncan K. Foley, "An Asset Price Model of Aggregate Investment," submitted for publication.

6. ———, and Roy Gardner, "Some Finite Sample Properties of Spectral Estimators of a Linear Regression," Working Paper 122, Department of Economics, Massachusetts Institute of Technology, December 1973.

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

8. B. Rosenberg, "The Analysis of a Cross Section of Time Series by Stochastically Convergent Parameter Regression," *Annals of Economic and Social Measurement,* Vol. 2, No. 4, October 1973.

9. A. H. Sarris, "A Bayesian Approach to Estimation of Time-Varying Regression Coefficients," *Annals of Economic and Social Measurement,* Vol. 2, No. 4, October 1973.

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

Other Computer-Oriented Activities

Electronic Data Processing for Research Support

In recent years a good deal of computerized economic analysis has become organized outside the conventional units of government, large business firms, and academic institutions. Some of this organization is based on special data collections—macroeconomic time series as well as microeconomic cross-sectional and longitudinal data—and some is centered around specific econometric models or other research and forecasting techniques such as cyclical indicator systems and input-output analysis.

These developments are to be welcomed insofar as they reflect the increased application of a powerful new technology and make information and high-level expertise available to users. They also provide some external economies by enhancing academic and on-the-job training as well as the experience of young computer specialists and computer-oriented economists. However, some of the enterprises exhibit also the characteristic shortcomings of spontaneous initiatives: duplication of effort, incompatibility of materials and programs, lack of standardization, and difference in quality of data and of documentation.

These developments are reflected in. recent changes of the Bureau's EDP operations in New York. In our external relationships we attempt, albeit in a modest way, to alleviate some of the shortcomings mentioned above. One type. of effort is formal and informal advice on the management of machine-readable time-series data banks. The Bureau's own data bank operations provide us with long-term experience in data bank management on many different computer systems, with many differently organized data sources. The fact that we are acquainted with data bank operations both as a user and as a producer provides us with an opportunity for balanced judgment on many issues. Our experience permits us to advise other organizations that are setting up new operations.

A number of governmental agencies, here and abroad, who wish to make their data available to the public in machine-readable form have asked our advice on organization, format, updating methodology, annotation, adjustment, documentation, and various other problems. Among the more important caveats, of value to new organizers, is the danger of getting locked into a particular software system.

Another public service is the provision, at cost, of our data bank of economic time series to any interested academic institution. The data collection is distributed on magnetic tape, copied to the specification of the computer center where it is to be used. It comes with a little retrieval program that can be used on any system supporting FORTRAN and with a printed directory and brief description of the series included. At present about eleven universities are using our bank. In addition to the tapes containing our time-series data bank, we are also making other data sets—largely consisting of

microdata—available to researchers inside and outside the Bureau. Our newly organized tape library (see below) will greatly facilitate this operation.

One outside activity that is most directly related to the new organizational developments is the organization of a series of workshops on the documentation and standardization of large machine-readable statistical data sets, under the auspices of the Bureau's Conference on the Computer in Economic and Social Research. The first workshop was held in mid-April 1974 and almost all members of the data processing unit participated. The workshop resulted in a first set of recommendations concerning minimum standards for (1) descriptions of physical and recording characteristics of magnetic tape, (2) documentation of time series, (3) library index cards describing data files, and (4) source book and code book documentation of survey data. These recommendations will be reformulated by subcommittees and circulated among members of the workshop. The resulting versions will be published in the *Annals of Economic and Social Measurement*. Since the suggestions originated in workshops including a variety of organizations and persons, we hope that the recommended standards will be accepted and adhered to. This, of course, does not exclude further improvements.

One other outside activity is the wide dissemination of our programs. We are currently witnessing a spurt of requests for the Bureau's business conditions analysis programs, largely from abroad. This spurt reflects increasing interest in national economic indicators in foreign countries as well as the Bureau's efforts to promote cooperation for the development of international indicators.

As far as internal Bureau operations are concerned, we are trying to promote the utilization, by the Bureau's research staff, of some of the facilities provided by the new outside organizations (such as the 1970 Census tapes from DUALabs and some collections of company data). We are also trying to overcome systems incompatibilities in other collections of data. As a result of these efforts we now have the beginning of a data library on magnetic tape consisting of several well-documented bodies of data

(some collected by the Bureau and some acquired from outside agencies) in addition to the 1960 and 1970 Public Use Sample Census tapes.

Our time-series data bank is being utilized by Bureau staff on several different computer systems—some time-sharing systems for interactive use (including NBER's TROLL for model building and simulation and Rapidata's Probe for current indicator analysis), and some systems for business cycle type of analysis and for plotting. Commercial providers of data banks, on the other hand, usually offer data together with machine time and software on a particular computer system, and the user is restricted to that system. An obvious disadvantage of such a setup is that the user is restricted to the software supported by the system—be it programs, econometric models, plotting facilities, languages or whatever; in some systems one cannot even use one's own programs. Our data bank is probably unique in that it is entirely system-independent.

We have made some exchange arrangements to enable our research staff to have access to specialized industrial and financial time series that are not contained and updated in our own data bank (Federal Reserve Bank of San Francisco). Similar arrangements are in the offing with some time-series data banks of other countries.

As a consequence of the availability of standard programs and of research assistants with some knowledge of programming and data processing, the tasks of our programmers have shifted from the writing and running of ad hoc programs to the screening, training, supervising, and consulting of research assistants, and to the solving of only the more complicated problems.

The programmers engaged in these tasks are Teresita Echaniz, Phyllis Goldberg, and Marianne Rey. Antonette Delak writes special programs for the data bank and the plotting operations. Martha Lichtenstein takes care of the smooth functioning of our terminals and other equipment. Constance Lim and Wan-Lee Hsu update the time-series data bank. They are supervised by Josephine Su, whose report about these operations follows.

Charlotte Boschan

NBER Data Bank

The Bureau's data bank of machine-readable economic time series is now in its fifth year. At present, the bank contains 2,260 economic time series (930 monthly, 570 quarterly, and 760 annual), as shown in Table II-4.

Most time series are available in the data bank

TABLE II-4

	A	Q	M
National Income and Product Accounts	744	397	30
Finance			
Money Stock Measures			19
Banking Series			26
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Other Series		46	78
	760	570	930

from 1946 or 1947 onward. The results of the consensus forecasts of the quarterly ASA-NBER Economic Outlook Survey are also included in the data bank.

The data bank is updated daily on the following time-sharing systems: Rapidata, General Electric's Information Management and Project System (MAP), the Service Bureau Corporation, and NBER's TROLL system. Boeing Computer Services will soon be added. We now have seventy-one subscribers through these four systems, of which eleven are nonpaying universities. Wharton EFA is in the process of putting their models on a time-sharing system. Once this is done, they will use the NBER data bank for their models.

We also provide magnetic tapes containing all time series to some time-sharing systems whose needs do not justify daily updating. Updated versions of these magnetic tapes are provided about once a quarter. The participating time-sharing systems in this group are Tymshare, Inc., and Time Sharing Resources. The magnetic tape version of the data bank has been provided to universities at minimum charges to cover our costs. Sixteen universities are now using our tapes.

Josephine Su

Annals of Economic and Social Measurement

The *Annals* has moved into its third year as a quarterly journal focusing on computer applications, data generation, and research methodology. This past year, special emphasis has been given to developments at the NBER Computer Research Center for Economics and Management Science and to conferences sponsored by the Conference on the Computer in Economic and Social Measurement. About half the issues of the *Annals* have been devoted to specialized topics, with the resulting special issues serving as reports on the state-of-the-art in rapidly growing fields. The speed of publication and unity of the issues makes the *Annals'* contribu-

tion to research greater than if the related articles were scattered in a variety of separate publications. In addition, introductory articles attempt to provide overviews of the fields for those not working on the research frontier. Other issues have contained articles generated in the NBER research program or relevant to this program.

Following the special issues on the Current Population Survey and Time-Varying Parameters in 1973 were special issues on Stochastic Control (January) and on Surveys-Microdata (April) in 1974. Both issues contained papers selected from those presented at meetings sponsored by the NBER Conference on the Computer in Economic and Social Measurement. Robert Ferber and Benjamin Okner coordinated the latter issue, and Gregory Chow and Michael Athans coordinated the former issue. This issue was the second one on Control Theory, making the *Annals* a major source for new developments in the use of this relatively new research tool.

The number of individuals who help to maintain the quality of the *Annals* seems to increase each year, with Gregory Chow and Edwin Kuh joining the Board of Editors; each has recently coordinated special issues. The other members —Phillip Cagan, Donald Farrar, John Meyer, Jacob Mincer, M. Ishaq Nadiri, and Christopher Sims—all contributed to the screening of articles and the development of editorial policy. John Kirsch has served ably as Computer Center Editor, both preparing NBER Computer Research Center Notes and screening manuscripts. Sydney Shulman, Assistant Editor, has continued her coordinating responsibilities in New York. In addition, many other NBER and non-NBER researchers have contributed to the review and evaluation of manuscripts. To those listed above, and to many not named here, must go the credit for keeping the *Annals* an informative, high-quality journal reflecting the NBER research program.

Sanford V. Berg