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1. ECONOMIC AND SOCIAL PERFORMANCE

PRODUCTIVITY, EMPLOYMENT, AND PRICE LEVELS

The current inflation and efforts to curb it have made this area of research particularly timely and urgent. The studies reported on here, financed mainly by grants from the Alfred P. Sloan Foundation and the Alex Walker Charitable and Educational Trust, deal with the improvement of price and productivity measurement, the explanation of price and productivity changes, and the impact of these changes on the production side of the economy. Some closely related questions are taken up in the Bureau's monetary studies, the forthcoming Universities-National Bureau Committee Conference on Secular Inflation, and two studies undertaken recently on the effects of inflation on financial markets and the role of prices in international trade, all discussed elsewhere in this report.

The first National Bureau publication from these projects was *The Behavior of Industrial Prices*, by George J. Stigler and James K. Kindahl, published last year. John Kendrick's book on *Postwar Productivity Trends in the United States* has been revised after review by a staff reading committee and has been submitted to the Board of Directors, and two additional manuscripts have been referred to staff reading committees.

Several preliminary articles at least partly derived from these studies, and eventually to be incorporated into Bureau reports, have been published or are in press. The published ones include the Nadiri and Rosen article on "Interrelated Factor Demand Functions," in the *American Economic Review*, September 1969, and Fabricant's "Prices in the National Accounts Framework: A Case for Cost-Benefit Analysis," in *The Review of Income and Wealth*, June 1970, and "Inflation and the Lag in Accounting Practice," in University of Kansas colloquium, *Accounting in Perspective*, South-Western Publishing Co., Cincinnati, 1971. Among others, soon to be published, are several articles by Fabricant, listed in his report below, and Robert Gordon's paper on capital measurement in a forthcoming issue of *The Review of Income and Wealth*.

Robert E. Lipsey

The Problem of Inflation

Since last year, in addition to the two published papers mentioned above, I have been working on the following:

"Labor Productivity under Modern Capitalism: The Case of the United States," in *International Conference on Industrial Economics*, Institute of Industrial Economics, Hungarian Academy of Sciences (in press).

"The 'Recession' of 1969-1970," in V. Zarnowitz (ed.), *The Business Cycle Today*, NBER (in press).

"Recent Economic Changes and the Agenda of Business Cycle Research," A Supplement to National Bureau Report 8, NBER, May 1971.

In one form or another, a good deal of the contents of these papers and of others that I have previously reported on will find a place in the volume on "The Problem of Inflation" that I am putting together.

The major point of the paper published in *The Review of Income and Wealth* is the need for better current information on prices, wages, and interest rates. The paper on "Inflation and the Lag in Accounting Practice" was described in an earlier *Annual Report*.

In the paper on labor productivity, I discuss, first, the longer-term changes in national output per manhour during 1889-1969, drawing on Kendrick's work; and, using Denison's calculations supplemented with some of my own, roughly estimate the contribution to growth in labor productivity of changes in the quality of labor, in the volume of tangible capital per manhour, and in technology and the

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other sources lumped together under "efficiency"—which, as usual, has to be measured by the "residual."

The second topic discussed in this paper is the typical pattern of change in labor productivity during business cycles, particularly, the rather general tendency of output per manhour to rise most rapidly during the first half of a business expansion, to slow down as the peak is approached, to rise least rapidly (or even decline) during the early stages of recession, and then to return to a more rapid rate of increase during the later stages of recession. The quarterly data of the BLS, now available for the economy at large beginning with 1947, confirm the pattern originally indicated by Hultgren's National Bureau studies of manufacturing and a few other industries.

A summary of the two papers on business cycles, which are also closely related to the subject of inflation (as is evident in almost any discussion of the current economic scene), is deferred to another section of this *Annual Report*.

The volume on "The Problem of Inflation" will cover short- and long-term changes in the structure as well as in the general level of prices; the historical relations of these price changes to other economic changes, particularly those associated with business cycles and the process of economic growth; the proximate and the more fundamental causes of price inflation; the nature and incidence of the burden of inflation under varying circumstances; and the practicability and social costs of policies used or proposed to deal with the problem of inflation. The limitations on what is known, and their implications for policy, will not be ignored. The larger part of the contents of so broad a survey has to be based on past and present research and will not be new to specialists. My intention is to address the volume to others concerned with the problem who wish to know something about its nature and the difficulties of dealing with it.

A key topic in the volume will be the extent and variability of price inflation in recent years. Price inflation—"creeping" or "galloping"—has characterized most of the postwar world. In only three of the forty-one countries listed in Table II-1 was the average annual rate of change in the general price level in 1955-69 less than 1 per cent, and in half of the countries the average rate of increase exceeded 4 per cent. Further, referring to details not given in the table, in only four countries were there as many as two or three years of price stability or decline; in six, prices failed to rise, or fell slightly, in just one year. In the other twenty-eight countries, every year between 1955 and 1969 saw a rise in the price level.

Noteworthy, also, is the fact that in the majority of countries—twenty-nine of the forty-one—price inflation was more rapid during the second half of the period covered than during the first half; and that, in almost every country, inflation followed an unsteady course from year to year.

Persistent price inflation will lead, sooner or later, to adjustments such as shifts in the relative rates of return of equity and debt securities; to the spread of variable annuities; to the introduction into contracts of escalator clauses or terms that anticipate the rises in the price level expected over the life of the contract—the list is not exhaustive. The more persistent inflation has been (unless offset by other factors), the stronger and the more widely diffused will be the efforts by the public to adjust to it. Fluctuations in the rate of inflation complicate the problem of formulating expectations, widen differences of opinion concerning the future, and magnify the difficulties of coming to terms in negotiations on wages, prices, and interest rates.

The strong tendency to adjust, in one way or another, to a rising price level raises an interesting question also about the social welfare implications of a given rate of inflation. A given per annum rate of increase in the general price level cannot mean quite the same thing, after it has persisted for some time and adjustments have taken place, as it meant before.

The same point applies, sometimes with greater force, to the welfare implications of other economic indicators, such as the rate of unemployment. Because

TABLE II-1
Average Annual Rates of Change in the General Price Level,
41 Countries, 1955-1969
 (per cent)

Region and Country	Average Annual Rate			Average Absolute Deviation from Mean, 1955-1969
	1955-1969	1955-1962	1962-1969	
North America				
Canada	2.6	2.1	3.3	0.9
Guatemala	0.1	0.1	0.1	1.5
Honduras	0.5	0.2	1.2	1.4
Mexico	4.3	4.9	3.6	1.3
Puerto Rico	2.6	3.2	2.6	0.9
United States	2.5	2.2	2.8	1.1
South America				
Argentina	26.0	33.8	21.5	11.7
Brazil	37.0	27.1	47.4	16.8
Chile	29.3	26.2	35.2	11.5
Colombia	11.4	9.6	13.2	4.3
Ecuador	2.7	1.3	4.1	1.7
Paraguay	8.2	14.3	1.8	5.4
Asia				
Burma	0.0 ^a	-0.5	0.5 ^a	3.0 ^a
China (Taiwan)	5.1	7.2	3.1	3.2
India	5.4 ^b	2.8	8.0 ^b	3.4 ^b
Israel	5.5	6.8	5.0	2.6
Japan	3.8	3.1	4.4	1.1
Korea (Rep. of)	14.3	12.5	15.9	7.0
Pakistan	3.5	4.1	2.9	3.9
Philippines	4.2	3.2	5.2	2.3
Thailand	1.6	1.4	1.8	2.1
Turkey	8.4	10.4	6.3	4.8
Europe				
Austria	3.4	3.4	3.2	1.2
Belgium	2.7	1.8	3.8	1.2
Denmark	4.7	3.5	6.0	1.6
Finland	5.4	4.8	6.1	2.4
France	5.2	5.8	4.3	2.0
Germany (West)	2.9	3.2	2.7	0.9
Greece	2.6	2.5	2.6	1.6
Iceland	11.9	10.6	13.2	3.8
Ireland	4.1	3.0	5.0	1.7
Italy	3.3	2.4	4.0	1.9
Netherlands	4.3	2.9	5.5	1.6
Norway	3.5	3.3	3.8	1.5
Portugal	2.7	1.4	4.1	1.8
Sweden	4.0	3.7	4.0	1.1
Switzerland	3.7	3.1	4.3	1.1
United Kingdom	3.5	3.3	3.7	1.3
Oceania				
Australia	2.8	2.5	3.4	1.6
New Zealand	2.6	2.1	3.1	1.3
Africa				
So. Africa	2.3	1.3	3.2	1.0

NOTE: The general price level is measured by the implicit price deflator for gross domestic product, extended where necessary by the available consumer price index. The basic data were obtained from publications of the United Nations. Averages are arithmetic means of annual percentage changes.

^a Through 1967 only.

^b Through 1968 only.

family incomes and reserves are higher today, more time can be taken to look for a job. Also, as Mincer's studies of the labor force inform us, shifts in recent years in the age-sex composition of the labor force have increased the relative number of "peripheral" or secondary workers. The unemployment rate of these workers is generally higher but also less serious—in terms of income and in other ways—than that of heads of households. In short, a 6 per cent unemployment rate in 1971 is not quite what a 6 per cent unemployment rate was in 1951. As is reported later in this section, the question is being studied by Hosek.

If neither the unemployment rate nor the inflation rate is a stable index of its corresponding dimension of welfare, another interesting question is posed. How are schedules purporting to show the trade-off between the national goals of reducing inflation and reducing unemployment to be interpreted?

Solomon Fabricant

The Short-Run Behavior of Prices

During 1970 prices rose about 5 per cent while unemployment climbed from 4 to 6 per cent, an unprecedented combination of events for the U.S. economy. The continued increase in prices ran counter to forecasts that the 1969-70 policy of slowing down the economy to curb inflation would begin to work during 1970. Explanations offered for the unexpected strength of inflation are of three kinds: (1) Anticipations of continued inflation in 1970 kept wages going up rapidly, delayed lay-offs and other steps which raise productivity, and created a climate in which continual price increases were accepted and thought necessary. (2) Prices are largely cost-determined, and costs rose in 1970 in a delayed catching-up to past price increases, but inflation would eventually peter out so long as aggregate demand continued slack. (3) Unions and oligopolies pushed up wages and prices in 1970 and would continue to do so unless unemployment and excess capacity rose to very high levels.

Further light can be shed on this process of inflation by examining how cost and profit changes are associated with price movements. Hultgren's data on prices, profits, and costs in fifteen industries, originally terminated in 1961, have been extended to the middle of 1970, and can be extended still further at a later date. I am comparing the recent experience with earlier periods, particularly the declines of inflation in the early and late 1950's. In those earlier episodes, the association between price and output movements was much closer. The questions are, How and why did that association change in 1969-70?

Phillip Cagan

Labor Market Models and the Rate of Inflation

The preliminary investigation of inflation prediction, which was described in last year's *Annual Report*, has been broadened in scope. A monograph currently near completion attempts to build several alternative labor market models, to make econometric estimates of model parameters using U.S. postwar data, and to test the fitted models in prediction tests that will be regularly updated. The project attempts to improve on previous research in this area in three main respects: (1) by more closely relating theoretical labor market models to empirical research on wages and prices than has been common in the past; (2) by exploiting previously unused data sources and by improving the construction of variables from existing data; and (3) by improving on the record of inflation prediction generated by previous price equations.

The most elegant theories based on purposive behavior, as constructed by Friedman, Phelps, and Lucas-Rapping, lead to the conclusion that an unemployment rate maintained by policy-makers below the "natural rate" of unemployment will lead to a continually accelerating inflation, but neither this conclusion nor the parameters of the underlying models have been validated econometrically for the

postwar United States. On the other hand, fitted econometric wage-price models, while containing price equations that in some cases are based on an explicit production function, do not postulate the explicit labor market behavior by individuals that the parameters of the wage equations are intended to describe.

The first model I am testing, Model I, is my formalization of the verbal labor market model with which Friedman supports the logical validity of the accelerationist hypothesis. This model postulates that workers and firms are always in equilibrium. Workers always obtain exactly the quantity of employment that they desire at the market-determined real expected wage, and firms obtain exactly the quantity of labor input they desire at the actual real wage.

In an alternative model, Model II, I have analyzed a labor market which is not necessarily in equilibrium. Labor demand may be too high, resulting in involuntary vacancies, or labor demand may be too low, leading to involuntary unemployment. While Model II is symmetrical in that it allows disequilibrium between the supply and demand for labor to persist either in a boom or a recession, the adjustment of the wage rate is governed by quite different mechanisms in each case, reflecting behavioral postulates that make the wage rate less flexible downward than it is upward.

The following are among the specific departures of Model II. First, the demand for labor by firms is not governed by the usual neoclassical production function, which assumes constant returns to scale, fixed capital, variable labor, and, thus, diminishing returns to labor and countercyclical fluctuations in labor productivity. Instead, Model II assumes that a portion of labor input is fixed; and that the input of capital services varies through changes in the number of machine-hours worked by a given stock of machines, thereby producing procyclical fluctuations in labor productivity that are consistent with observed facts. Second, firms are in disequilibrium in a period of an excess demand for labor. They try to fill vacancies by bidding for an inelastic supply of primary workers (thus increasing their wage), and by attempting to supplement these workers with lower-productivity workers who, in many cases, must be induced to enter the labor force. Third, the formal analysis of periods of excess demand introduces the role of uncertainty in comparisons of wage offers and wage expectations by workers considering job changes. This factor may invalidate the accelerationist hypothesis. Fourth, in periods of insufficient demand, workers do not voluntarily leave their jobs and seek other employment as a result of a cut in wage rates. They leave involuntarily without (in most cases) any change in wage rates, because firms (a) are reluctant to cut the wages of their existing employees and (b) insist on paying all employees equal pay for equal work. A position of underemployment may be reached in which workers are neither on their positively sloped labor supply curve, as assumed by Friedman and Lucas-Rapping, nor on a horizontal labor supply curve, as assumed by some post-Keynesian writers, but are involuntarily off their labor supply curve. The latter, however, soon shifts downward as the duration of unemployment lengthens. Finally, the asymmetrical treatment of booms and depressions explains why the accelerating deflation predicted by the Friedman and Phelps models for periods of underemployment did not in fact occur either during postwar recessions or during the 1930's.

Robert J. Gordon

Problems in the Measurement of Nonresidential Fixed Capital

During the past year research was completed on a preliminary report, "Measurement Bias in Price Indexes for Capital Goods," which will appear in *The Review of Income and Wealth*, June 1971. The paper's main contribution is to summarize most of the empirical literature on measurement errors in official U.S. deflators for structures and for producer's durable equipment, and to compute, both from previous work and new information of several different types, a revised capital goods price index. This series rises much more slowly over the 1954-63 period

than the official index, and *declines* relative to a revised price index for consumption during this period. This is in contrast to the usual view that the price of capital goods has been rising relative to the price of consumption.

The first section of the paper reviews the evidence on the relation of transaction to list prices, and presents new results based on unit value data from the *Census of Manufactures*. Both sets of evidence suggest that the ratio of true buyers' prices to sellers' list prices moves procyclically. This implies that a true measure of real output fluctuates less over the business cycle than the official real output measures that are computed from deflators based on list prices. More surprisingly, both sets also suggest that there is a secular upward trend of list prices relative to transaction prices.

The discussion of quality change begins with a formal statement of the proposition that a quality change index should adjust for any increase in the ability of a capital good to contribute to production. Then two empirical techniques of quality adjustment are described and compared: the conventional methodology used in existing official U.S. price indexes and the hedonic regression technique. The methods are similar in principle: both can measure some, but not all, quality change, and both are more useful when used together rather than separately because their defects are complementary.

The next section is devoted to a review and evaluation of the empirical evidence on the importance of quality change in producers' durable equipment; most of the results imply that there is a substantial upward bias in existing price indexes. The new and old empirical evidence is combined to compute a revised deflator for total producers' durable equipment, which rises about 2 per cent per annum more slowly, over the 1954-63 period, than the official index.

The deflation of investment in structures is inherently less tractable than that in equipment because of the heterogeneity of buildings. A number of new structures' indexes are reviewed, the best of which (the FHA/OBE deflator for single-family houses) is available for the post-1953 period but has not been cited or discussed previously. Other techniques evaluated include a hedonic regression index for single-family houses, which was recently initiated by the Bureau of the Census, surveys of labor requirements for different kinds of structures, and surveys of housing market values as reported by individual homeowners.

The paper concludes by combining the detailed adjustments of the equipment deflators and some rough adjustments of the structures' deflators to produce a deflator for total fixed investment, which rises only 4.3 per cent between 1954 and 1963, in contrast with a 13.4 per cent increase in a revised consumption deflator and a 22.1 per cent rise in the official U.S. deflator for fixed investment.

During the next academic year work will proceed on the research agenda published in last year's *Annual Report*, and a monograph on capital measurement should be completed before the publication of the next *Report*.

Robert J. Gordon

Interrelated Factor Demand

In this study an attempt is made to formulate an integrated dynamic model of the firm. The model provides for interactions and feedbacks among the stock variables such as the number of production and nonproduction workers, capital and inventories, and the flow variables such as the rate of utilization of capital and hours worked. From the estimates of the structural equations the distributed lag pattern for each variable can be generated and the long-run elasticities of the dependent variables with respect to the exogenous variables such as sales, relative prices, and time trend can be obtained.

The model is fitted to quarterly data for manufacturing industries for the period 1948I-1967IV. The results for the total manufacturing, total durables, and total nondurables industries have been completed and are currently being written up. The period 1968I-1970II is used to test the stability and forecasting performance

of the model. The results for these industries are very encouraging. Implied distributed-lag responses show that the stock of physical capital is relatively fixed compared with other inputs, and that the primary role of variations in utilization rates is to adjust output levels rapidly in the face of the slow adjustment of stocks. The number of nonproduction workers interacts with capital stock, its rate of utilization, and the level of inventories. There is no strong evidence of substitution or complementarity between numbers of production and nonproduction workers in these industries. The model explains well the "puzzle" in the short-run production function, i.e., the less than unitary elasticity of labor with respect to output; the high short-run returns to labor input found in many studies seem to be due to the omission of the utilization rates, particularly that of capital.

The model has also been fitted to the data for fifteen disaggregated two-digit manufacturing industries for the period 1948I-1967IV. We are now analyzing the interindustry differences in the estimates of the model. Specifically, we are interested in exploring the reasons for differences in the adjustment patterns of the variables in different industries.

M. Ishaq Nadiri
Sherwin Rosen

Stability of Equilibrium When Individual Firms Make Price Adjustments

Existing theories of competitive disequilibrium lack an explicit mechanism for price adjustment. They fail to explain how, if all participants take price as given, prices can actually change. In the present project, models of disequilibrium are constructed in which individual firms adjust their own prices, still believing that there is a competitive market price in a somewhat generalized sense. The stability properties of such models are examined.

The first part of this project concerned a highly stylized model of an individual market. It was shown that under very broad assumptions about the way in which customers search for low-priced firms, stability will be achieved. The resulting paper was published as "Quasi-Competitive Price Adjustment by Individual Firms: A Preliminary Paper," *Journal of Economic Theory*, Vol. 2, No. 2 (June 1970), pp. 195-206.

The major part of the project concerns models of general equilibrium rather than partial ones such as that described. A paper entitled "On Price Adjustment Without An Auctioneer" has been completed and submitted to the *Review of Economic Studies*. In it, the assumptions made by Kenneth Arrow and Frank Hahn, in their forthcoming book on general equilibrium, as regards the so-called "Hahn process" are shown to be more naturally applied to a model in which individuals adjust their own prices than to models of the more standard type. A stability theorem for such a model is then proved.

Plans for future work include the extension of the preceding to cases in which individual firms have locational or other advantages (relative to certain consumers) which make them more likely to be found, given their price, in the search of consumers for low-priced firms. I also hope to relax some of the stringent assumptions made in the paper just discussed as to the way in which consumers search, and to investigate the consequences of allowing repeated random sampling of firms. This will presumably involve theorems about the asymptotic probability that equilibrium is attained.

Franklin M. Fisher

NATIONAL INCOME, CONSUMPTION, AND CAPITAL FORMATION

Introduction

The work of John Kendrick and Richard and Nancy Ruggles is now either completed or well along. The Ruggles' book, *The Design of Economic Accounts*, was published last year. Kendrick's work on total investment is now in the writing

stage and his project on imputations in the national accounts is still in process. Current plans call for preparation of a monograph by Kendrick which will draw on the work of Jennifer Rowley, Elizabeth Wehle, and Harold Wolozin on, respectively, the value of students' time, the value of unpaid household labor, and the value of volunteer labor. Robert Eisner's nonincome-income project involves a series of doctoral dissertations in the measurement of income and output. One of these (McElroy on Capital Gains) has been completed, and several others are in draft form.

The joint NBER-Census Bureau project on household capital formation and savings is also close to completion. The work on time-series models of consumer durable goods demand has resulted in two papers, jointly authored by myself and Paul Wachtel; these are currently being revised in the light of comments from staff reviewers. Analysis of the consumer anticipations survey data has resulted in two papers by Michael Landsberger. The household capital formation project has been supported in part by a grant from the National Science Foundation, as has Eisner's nonincome project. All these studies are reported in detail below.

We are applying to the National Science Foundation for an exploratory study grant that would permit us to begin systematic investigation of a more welfare-oriented measure of total output. The research proposal contains, among others, sections dealing with measurement of the social and economic costs of changes in the physical environment, the measurement of output in areas relating to health and medical economics, the measurement of environmental disamenities associated with urbanization, and studies in the allocation of nonmarket time. We anticipate that some of these projects will be joint efforts involving other research organizations.

F. Thomas Juster

Household Capital Formation

Work on the time-series analysis of consumer outlays on durable goods is almost completed. Two manuscripts, jointly authored by myself and Paul Wachtel, have been completed. One, titled "Anticipatory and Objective Models of Durable Goods Demand," has been circulated to a staff reading committee and is presently being revised. The other, titled "A Note on Uncertainty, Expectations and Durable Goods Demand Models," is also being revised and will be completed this summer. Both papers were discussed extensively in the 1970 *Annual Report*. In addition, we are preparing a paper for the August 1971 meetings of the ASA, which will deal with the use of ex ante data on household savings.

Work on the ex ante experimental survey, being conducted in conjunction with the U.S. Bureau of the Census, has proceeded rather slowly during the past year. All five originally scheduled surveys have now been completed, although the fifth was completed some months later than planned due to budgetary constraints. We are now in process of merging the data tapes from the five interviews onto a single master tape, and should shortly be in a position to examine substantive problems.

Michael Landsberger, who joined the National Bureau staff this year, has been working with the first of these five waves of interviews. He has concentrated on use of the experimental survey data to examine labor force participation and consumption decisions. Landsberger's findings are summarized in a separate report below.

F. Thomas Juster

Optimal Time Allocation Within the Family

A formal model of optimal time allocation of family members has been developed. The general theoretical constructs underlying this model are those developed by Gary Becker and Jacob Mincer. The basic assumption is that family members are producing commodities which are the arguments in the family's utility function, and that these commodities are produced by combining goods bought on the

market with the time inputs of family members. The problem is to determine the amount of time that particular family members (empirically, husband and wife) should put into home activity in order to maximize the utility function of the family. The decision about time allocation determines earnings and, therefore, the consumption of the family. Thus, earnings and consumption are determined simultaneously, an approach which is strikingly different from the traditional approach to consumption theory.

Important factors which affect the allocation of time and, hence, consumption are the number of children in the family and their age distribution. The model developed here suggests that the presence of young children has a negative effect on the consumption expenditure of the family. This effect decreases as the children grow older and eventually, for older children, becomes positive. This proposition provides a theoretical explanation of the effect of children in various age groups on consumption, a factor which has been ignored by the traditional approach to the consumption function. The empirical tests provide strong support for this proposition. Another proposition, which arises from the model in the context of the consumption function, is that the husband's wage rate has a stronger effect on consumption than the wife's wage rate.

The model also implies that children have a positive effect on the level of market activity of the husband, and that this effect is a decreasing function of the age of the children. The presence of young children should tend to reduce the level of market activity of the wife. The strength of this effect, however, decreases with the age of the children in algebraic terms, and may eventually become positive. These propositions are also strongly supported by the empirical evidence.

Another implication of the model is that the higher the wage rate of the husband, the lower the level of the wife's market activity. This effect is symmetric; that is, an inverse relation should also be found between the wage rate of the wife and the level of market activity of the husband. If there are young children in the family, both husband and wife tend to respond less to a change in their wage rates as far as their level of market activity is concerned.

The effects of lags and imperfect markets on the estimates of the parameters is being explored, although this part of the study is only in its initial stages.

Michael Landsberger

Studies in the National Income Accounts

Revised estimates have been completed of total investment (tangible and intangible), by sector, and of the resulting gross and net capital stocks, in current and constant dollars, 1926-66. A first draft of notes on sources and methods used in the estimates has also been completed. During the coming year, the technical notes will be edited, analyses carried out, and findings written up—at least in preliminary form.

As a by-product of the project on total investment and capital stocks, estimates have been developed of the imputed rental values of nonbusiness capital goods, and of the opportunity costs of schoolwork by students of working age. Estimates of the imputed values for a number of additional nonmarket activities are virtually complete. Analysis and write-up of the estimates of imputed values are being deferred until completion in 1972 of the work on total investment, capital, and economic growth.

John W. Kendrick

Measurement and Analysis of National Income (Nonincome Income)

A session at the Detroit meetings of the American Statistical Association in December was devoted to reports of work in nonincome income. After a foreword by Robert Eisner and Arthur B. Treadway, papers were presented by Michael McElroy on "Capital Gains and the Concept and Measurement of Purchasing Power," Allan I. Mendelowitz on "The Measurement of Economic Depreciation,"

and Wolfhard Ramm on "Measuring the Services of Household Durables: The Case of Automobiles."

McElroy estimated net money capital gains as averaging 25.3 billion 1958 dollars over the 1946-68 period. The OBE measure of disposable income averaged 326.9 billion 1958 dollars over the same period. McElroy, therefore, presented adjustments of real disposable income which averaged almost 8 per cent in an upward direction over the post-World War II period. While capital gains, heavily influenced by movements of security prices, show very substantial year-to-year fluctuations, their aggregate was negative in only five of the twenty-three years under consideration, and their mean indicated a substantial positive average addition to conventionally measured disposable income.

McElroy reported that inclusion of capital gains sharply altered estimates of the size distribution of income. Estimates for 1958, a year of high aggregate capital gains, indicated that, while those with incomes of \$15,000 and over (before taxes) received 16.5 per cent of total income after taxes, this share was raised to 27.7 per cent of total income when capital gains were included. At the other end of the income scale, inclusion of capital gains lowered the share of those receiving less than \$4,000 from 14.2 per cent to 11.4 per cent of total income after taxes. Estimates of the burden of federal, state, and local taxes by income class suggest that, when capital gains are included as income, families with incomes over \$15,000 do not pay a larger per cent of their total income in taxes than others.

Mendelowitz reported estimates of economic depreciation derived from relations between capital expenditures and subsequent gross revenues of individual firms. Pooling both cross-section and time-series data, he derived revenue time paths stemming from capital expenditures of manufacturing firms. On the assumption that the actual and anticipated time paths of revenue were equal, the time paths of asset values as a function of expected future revenues were calculated as functions of various rates of discount. Using time-series estimates and a 10 per cent rate of discount, economic depreciation for manufacturing corporations in 1969 was estimated as \$16.11 billion; estimates for earlier years are lower. Using a discount rate which equates the sum of revenues to original cost (21.1 per cent), 1969 depreciation charges are estimated at \$14.09 billion. These estimates compare with figures of \$17.33 billion for straight-line depreciation and \$20.14 billion for sum-of-the-years digits depreciation. While the estimates are preliminary and subject to substantial refinement, they suggest that economic depreciation is actually less rapid than depreciation widely used for book and tax accounting purposes, a finding contrary to widely held views. The differences between these and more traditional estimates result from the finding that revenues from capital acquisitions appear to hump after several years, perhaps as they come into fuller use, along with the fact that discounting tends to make an asset rise in value as expected future revenues come closer in time.

Ramm applied techniques similar to those used for the construction of hedonic price indexes to derive estimates of investment, depreciation, rental services, and consumption in automobiles. Using "Blue Book" prices, Ramm grouped some 8,980 observations on specific types and models of automobiles in eight cross sections, one for each calendar year from 1961 through 1968. He employed nine variables, some of them dummies, relating to characteristics of the autos, as well as dummy variables for age, in a number of cross-section regressions.

Depreciation variables were finally estimated from single-year, adjacent-age regressions, thus permitting estimates of depreciation to vary from year to year and, of course, to differ from age to age of the automobile stock. In a similar manner, price changes unrelated to depreciation were estimated by pooling data for adjacent years, one age at a time. Depreciation rates from ages zero to six were generally, although not always, found to be an increasing fraction of remaining asset value. For example, depreciation rates on a declining balance basis, for each of the successive ages from zero to six, were .8420, .7983, .7735, .7433, .7266,

.7539, and .6803 for 1968. Estimates of price variation, however, indicated some evidence of capital gains, particularly on older cars.

Using new automobile finance rates as the base for computing interest costs, Ramm estimated consumption services from automobiles as ranging from \$21.6 billion in 1962 to \$31.78 billion in 1968. Gross automobile investment rose from \$16.03 billion in 1962 to a peak of \$28.2 in 1966 and was estimated at \$24.91 billion in 1968; net investment, however, was only \$.53 billion in 1962, reached a peak of \$7.08 billion in 1966, and amounted to \$4.06 billion in 1968. While money capital gains were positive in each year except 1965 and 1966, they were on balance slightly negative when converted to real terms.

The papers by McElroy, Mendelowitz, and Ramm, along with the foreword by Eisner and Treadway, appeared in the *1970 Proceedings of the Business and Economic Statistics Section* of the American Statistical Association. A full report of McElroy's work is also available in his doctoral dissertation, "Capital Gains and the Theory and Measurement of Income," Northwestern University, 1970, and similar further reports will be available from Mendelowitz and Ramm shortly.

Work is continuing by John Soladay on income and investment in natural resources, by Robert Wallace on income and investment in education, and by Stephen Zabor on executive compensation. A volume combining reports of all these research undertakings is contemplated.

Robert Eisner

Economic and Social Accounts

The Design of Economic Accounts was published in November 1970. Continuing research on the development of economic and social accounts is focused on three aspects of the system: (1) the investigation of techniques for making macro estimates from micro data, (2) subsector disaggregation of income accounts and balance sheets for the household and enterprise sectors, and (3) the development of micro data sets with the objective of developing social as well as economic accounts.

With respect to creating macro estimates from micro data, research is being carried out on the creation of price indexes from micro price observations. The present research indicates that it may be possible to develop more accurate price indexes based on fewer observations by altering the strategy of price collection, using knowledge previously gained about price behavior as a guide to future price collection. A paper is being prepared on this topic.

With respect to subsector disaggregation and the extension of the economic and social accounting system to the micro level, several papers have been written. A paper entitled "Macro Accounts and Micro Data Sets" was presented in December 1970 at the Detroit meetings of the Allied Social Science Associations. A paper entitled "The Evolution of National Accounts and the National Data Base" has been prepared for the fiftieth anniversary issue of the *Survey of Current Business*.

Nancy and Richard Ruggles

PUBLIC FINANCE

The Redistributive Effects of Alternative Tax and Expenditure Programs

Continuing in the directions suggested two years ago by the NBER Tax Studies Committee, Carl Shoup and I have prepared a proposal for a study of federal revenue sharing and assumption of welfare costs. The research is designed to provide a simplified, closed model for the evaluation of federal policy substitutions generally, with specific attention to the various revenue sharing and welfare proposals currently being debated at the federal legislative level. Related to this, I have proposed an extension of the analysis to the identification of the regional and local implications of several existing and proposed federal tax, expenditure, and transfer programs. External funding has been sought for both studies.

As an initial effort at closed system evaluation of a major fiscal change and to provide support for the research proposals, I have prepared a paper examining the redistributive implications, at the state level, of the Administration's currently pending "general revenue sharing" program. The analysis employs a closed model identifying the cost as well as the benefit incidence of the revenue sharing program under two alternative sets of financing assumptions (a personal income tax surcharge and a categorical grant substitution). The analysis is restricted to "initial impacts," i.e., it examines neither possible responses at the state-local or federal levels to the introduction of the program nor other re-equilibrating reactions. It also does not explore effects on the size-distribution of income.

The major conclusions are: (1) revenue sharing financed through a personal income tax surcharge redistributes income from urban to rural states and from high-income to low-income states; (2) the over-all redistribution effected by special purpose or categorical grants is even more discriminatory against urban states, but is to some degree beneficial to high-income states at the expense of low-income states; and (3) in consequence, the substitution of revenue sharing for categorical grants redistributes income from rural to urban states and from high-income to low-income states. A more realistic assumption than that of proportionate changes in categorical grants might significantly alter these conclusions.

This paper, entitled "An Alternative View of the Nixon Revenue Sharing Program," will be published in the *National Tax Journal* in a special June 1971 issue devoted to intergovernmental fiscal relations. A second paper, on revenue sharing and welfare, is currently in preparation and will be presented at the opening general session of the 1971 meetings of the National Tax Association.

Stephen P. Dresch

The Cost and Incidence of Tax/Transfer Alternatives for Canada

This study will present a fairly rich array of information on the distribution of characteristics of Canadian individuals and families; descriptions and data relating to initial incidence of existing tax/transfer programs; costs and incidence effects of reforms now being discussed and of hypothetical alternatives; and an evaluation of these proposals in terms of equity criteria, effectiveness in reducing poverty, and relationships to other policies for income improvement.

Last year the government of Canada published a White Paper entitled "Income Security for Canadians" which contains proposals for changes in the welfare system. The government of Quebec has also recently produced proposals for substantial changes in social policy. Both sets of statements include recommendations regarding the treatment of the elderly, changes in the family allowance program, and an approach toward a general guaranteed annual income. The costs, incidence effects, strengths, and weaknesses of the proposals will be reviewed in this study.

A simulation model utilizing individual and family income data from a 1968 sample survey made by the Dominion Bureau of Statistics has been designed and tested. An initial set of transfer program simulations has been run, and a preliminary draft covering this work and documenting the data and the model is in progress.

John Bossons
Colin J. Hindle
T. Russell Robinson

Negative Income Taxation and Poverty in Ontario

The objectives of this research are to determine the incidence of poverty in Ontario and to test the efficiency of alternative means of eliminating poverty. Some results were given in last year's *Annual Report*. A draft manuscript has now been completed.

Colin J. Hindle

The Effects of Alternative Unemployment Insurance Programs

The scope of our research remains essentially as described in the *1970 Annual Report*. While the unexpectedly late availability of data has slowed empirical work, progress has been made on the development of a model of the duration of unemployment.

In the model the unemployed worker is viewed as a job searcher who faces a stochastic wage offer distribution. The searcher's goal is to maximize the discounted value of lifetime expected income, and in order to do so he must select optimal values of the two variables under his control: acceptance wage and search intensity. One purpose of the model is to provide a rationale for the inclusion of certain personal or demographic factors into the analysis of unemployment behavior. These factors, which include sex, marital status, dependency status, and assets, presumably enter mainly on the supply side. However, empirical work is needed to establish their importance. A second purpose of the model is to illustrate the implicit trade-off between acceptance wage, search intensity, and the expected duration of unemployment. Thus, for example, a parametric change leading to an increase in the equilibrium values of both acceptance wage and search intensity would have an ambiguous effect on expected duration, since an increase in acceptance wage, *ceteris paribus*, tends to increase expected duration, while an increase in search intensity, *ceteris paribus*, has the opposite effect. A good deal of work remains to be done on the model, especially on the important question of the relationship between the duration of unemployment per spell and the number of spells per year. Our intention is to coordinate further modelling with ongoing empirical work.

James Hosek
John Bossons

Financing Higher Education

Under a service contract with the NBER by the Ford Foundation, I have devoted much of my time in recent months to the exploration and evaluation of various proposals for income contingent repayment loans to post-secondary school students. From a little-known proposal by Milton Friedman over fifteen years ago,¹ the concept of contingent repayment education loans has gained increasing currency as a result of the growing financial problems of institutions of higher education. Since 1967 a number of steps have been taken in this direction: (1) A federally sponsored panel (the Zacharias Panel) has proposed a national "Educational Opportunity Bank" to make income contingent loans.² (2) The Sloan Foundation has supported several research and analysis efforts, most notably that of Karl Shell's MIT group.³ (3) The Ford Foundation has appropriated funds for research, development and design of demonstration programs. (4) Yale University has launched a major income related payment program (the tuition deferment option), which has been adopted in a more restricted way, by Duke University.

The Ford Foundation's interest in the concept was an outgrowth of the serious study devoted to it by Yale, which culminated in the "Yale plan." As a technical advisor to the Foundation, I studied various proposals, monitored the development of the Yale program, explored the possibilities of extending it to other institutions

¹ Milton Friedman, in R. A. Solo, ed., *Economics and the Public Interest* (New Brunswick: 1955). A somewhat similar, though more extensive, proposal was made by James Tobin, "Raising the Incomes of the Poor," in Kermit Gordon, ed., *Agenda for the Nation* (Brookings: 1968).

² *Educational Opportunity Bank: A Report of the Panel on Educational Innovation* (Washington, D. C.: U.S. Government Printing Office, August 1967).

³ Karl Shell *et al.*, "The Educational Opportunity Bank: An Economic Analysis of a Contingent Repayment Loan Program for Higher Education," *National Tax Journal*, Vol. XXI, No. 1 (March 1968).

and to other areas of education, and examined the numerous public policy, financial and legal facets of this type of loan program.

Since the Yale decision to implement the tuition deferment option in the fall of 1971 (without Foundation support), I have devoted my efforts to the design of a national educational investment fund, which could initiate, on a private basis, a broad range of experimental innovations in more flexible forms of student finance. The function of the Fund would be to provide an integrated and coherent test of a number of specific deferred payment options. As an input into this design effort I have developed a general analysis of deferred payment plans, identifying the generic characteristics of what I have called "variable term loans," and have begun the empirical analysis required to identify financially viable (zero-profit) experimental options. This work will help guide the development of the Foundation's programs and will result in an extensive monograph entitled "Variable Term Loans for Higher Education—Analytics and Empirics," which I expect to complete by early summer (1971). My current work is focused on the legal and financial problems associated with the private implementation of an experimental national program.

In these various efforts I have benefited from the advice, assistance, and criticism of a number of individuals, most importantly Marshall A. Robinson of the Ford Foundation, Robert W. Hartman of the Brookings Institution, Dwight B. Crane of the Harvard Business School, John A. Humbach of Breed, Abbott and Morgan, and Robert D. Goldberg of the NBER.

Stephen P. Dresch

An Input-Output Analysis of Tax Substitution

This study investigates, by input-output analysis, the possible first-round price effects resulting from a partial replacement of the federal corporate income tax by a consumption-type value-added tax (VAT). Prices are defined here in terms of costs of primary inputs and ad valorem taxes and are expressed by indexes whose base is their level before the tax change.

The price change of each sector and of each component of final demand is examined under the following conditions: (1) We allow for a uniform reduction of the initial average corporate income tax rate for each industry. (2) VAT is invoiced on all purchases, based on VAT-exclusive value, with imports included and exports excluded. Refund, however, is allowed for all intermediate purchases including gross investment. (3) The VAT is set at a rate such that the government's tax revenues will purchase its original bundle of goods and services at the new prices, leaving its initial budget surplus or deficit unchanged in money terms. (4) The reduction of corporate income tax is either partly or totally shifted forward, while the VAT is totally shifted. (5) The original bill of final demands and the input-output structure remain the same.

Under these conditions the relationship between the reduction in corporate income tax and the role of VAT can be established; and the effect of the tax substitution upon the structure of industrial prices determined.

The analysis is being applied to the U.S. economy for the year 1969. The application requires data on input-output relations, depreciation for particular input-output cells, and corporate income tax liability by industry. These data and the related computations are being prepared by Cybermatics, Inc.

David Stout
An-loh Lin

Effect of Taxation on Personal Effort

I have continued with the drafting of a report on this project—whose scope and some preliminary findings were set forth in previous annual reports—concentrating particularly on the income and tax deduction characteristics of high-salary recipients.

Daniel M. Holland

2. URBAN AND REGIONAL STUDIES

INTRODUCTION

As the individual reports included in this section indicate, the urban and regional studies program at the National Bureau developed rapidly during the past year. All of the econometric studies of the housing market made good progress, and we completed programming of a crude prototype version of the National Bureau Urban Simulation Model. Preliminary reports on both the model and the econometric studies were the subject of a two-volume report to the Department of Housing and Urban Development.¹

The first version of the NBER Urban Simulation Model was loosely calibrated to Detroit data, and a limited number of simulation runs were executed successfully. Although the computer model operated correctly, the results of the simulations were predictably unsatisfactory. The major shortcomings of the Detroit prototype stemmed from satisfactory calibration of the model's submarket demand equations and incorrect estimates of the submarket housing process. These problems were due primarily to the unavailability of some critical data. In his econometric work, Dresch devised a number of ingenious ways to circumvent this deficiency but it proved fatal when we attempted to calibrate the model to Detroit. After considering several alternative methods of using Detroit data to deal with this problem, we determined that a more promising course would be to recalibrate the model on a more suitable body of data that recently became available for Pittsburgh.

Ingram and Ginn are now using the Pittsburgh data in an attempt to solve the underlying estimation problems. They are also altering the model's structure to allow the introduction of neighborhood quality as a zonal attribute and to incorporate a larger number of residence and workplace zones. These changes, which have been achieved with little or no increase in computational cost and time, should improve both the model's realism and its theoretical properties.

Although a great deal of research and development remains to be done before the NBER model can be regarded as a reliable and useful policy simulation and evaluation tool, our experience and progress to date make us confident of the approach taken. Further development of the model should improve our theoretical understanding of the processes of urban growth and provide insights into the effects of public policies upon them. Progress in developing and testing the model will depend on our ability to obtain further support for the project.

Development of the NBER model has depended heavily on the several econometric investigations of the housing market described in the individual reports that follow. In particular, Dresch's submarket demand study and research by Brown and Kain on the determinants of moving behavior provided parameters for the Detroit prototype. The econometric studies by Straszheim and by Kain and Quigley have generally confirmed hypotheses used in constructing the model and have suggested a number of improvements in its design. These latter studies should provide valuable guidance in introducing both neighborhood quality and racial discrimination into the model. Although such extensions will be difficult, they are essential if the model is to become a useful tool for policy analysis.

This year Quigley began still another econometric study of the housing market employing the same data Ingram and Ginn are using to calibrate the urban simulation model. In his research Quigley is addressing a number of theoretical, conceptual, and estimation problems that remain central to development of the model. We expect that his research will both add to our general understanding of the housing market and indicate specific ways to improve the theoretical structure and empirical validity of the Pittsburgh version of the NBER model.

The contributions of the several econometric studies are by no means limited

¹ A more detailed review of the HUD studies appears in Part I of this *Annual Report*.

to their part in the Urban Simulation Model building project. As the individual descriptions of these research projects indicate, all of them have made significant contributions to improved understanding of housing market behavior.

John F. Kain

DETERMINANTS OF MOVING BEHAVIOR

At any moment in time, a household demands a particular collection of housing characteristics, including location, number of rooms, size of lot, quality of unit, and quality of neighborhood. The household's demand for these various attributes depends upon the size and composition of the family, its income, and the location of the workplaces of the family members. A change in any of these factors alters the type of housing the family wishes to consume. In order to change housing attributes, it is usually necessary to change residences. Our research attempts to determine the relative influence of changes in demographic or life-cycle variables, in income or wealth, and in workplace location on the likelihood of intrametropolitan moving. The intrametropolitan moving rates by household socioeconomic characteristics, discussed below, are the empirical foundation of the household moving rates used in the NBER Urban Simulation Model.

The principal body of data used for analyzing moving behavior was obtained from the Bay Area Transportation Study Commission (BATSC). In addition to the usual origin-destination survey, BATSC conducted a more extensive home interview of 3,000 households. This supplemental survey provided a ten-year (1955-65) residential, employment, and household history for each of the households.

In an examination of moving rates by household age, family size, education, and income, the largest differences in moving rates are related to age. Over 40 per cent of households headed by a person less than twenty-five years of age move each year; by comparison, only 5 per cent of households whose head is over sixty years of age move each year.

Differences in the cost of moving for those who own versus those who rent have a strong effect on the rates of moving. Only 3 per cent of households that own move, while nearly 29 per cent of households that rent move. Furthermore, the large differences between moving rates of owners and renters remain even when age, education, income, and family size are recognized. Roughly 9 per cent of the owners under thirty move compared with 44 per cent of renters under thirty.

A unique feature of the Bay Area sample is the information it provides on the employment and residence histories of heads of households and the possibilities it offers for relating job changes to residence changes. The data indicate a strong association between these variables. Of the household heads who changed workplace, nearly 26 per cent changed residence, while only about 11 per cent of household heads who did not change workplace changed residence. Household heads who changed their workplaces to more distant locations were more likely to move their residence and to move outside the original neighborhood.

Age, tenure, and workplace changes have the most substantial effects on moving. The moving rates for the combination of these three factors indicate that younger households have higher moving rates; renters have moving rates roughly five times as high as owners; and households with heads who change jobs have rates roughly twice those of other households.

Controlling for tenure and job changes, households with larger family size, with higher incomes, and with head having more than a high school education, have higher moving rates. In all cases, households that rent or that have job changes have substantially higher moving rates than households that own or that do not have job changes.

H. James Brown
John F. Kain

Many of the central hypotheses of housing choices by urban households have been inadequately tested due to the lack of detailed information on the socio-economic characteristics of housing consumers and of satisfactory descriptions of the bundles of residential services consumed.

This project tests a number of hypotheses about the nature of the housing bundle, particularly its complexity and heterogeneity, and the determinants of household demand for specific attributes of these bundles. The analysis is based upon a detailed sample of 1,200 households and dwelling units in the St. Louis metropolitan area.

The sample includes information describing not only the socioeconomic attributes of the households but also the attributes of housing consumed. Particularly significant is the serious attempt made to measure qualitative aspects of housing bundles. The sample thus includes detailed descriptions of the residential quality of the dwelling units, structures, parcels, blockfaces and neighborhoods associated with the sample households.

The analysis is divided into three major areas: the valuation of the bundle of residential services, the determinants of home ownership, and the demand for (or consumption of) residential services by urban households. In the first section a series of alternative econometric models are developed which depict individual housing prices as a function of the qualitative and quantitative attributes of the dwelling unit, the structure, and the neighborhood.

The second section develops a series of microeconomic models to investigate the probability of home ownership or home purchase as related to the socioeconomic attributes of resident households. Particular attention is paid to evaluating the influence of the life-cycle of the typical family upon their tenure decision.

The third section estimates consumption or demand equations for individual components of the housing bundle, making use of the relative prices of the bundle of services as well as the socioeconomic determinants of demand.

Throughout these analyses, a serious attempt is made to recognize and to document the market effects of housing discrimination and the effects upon black consumers. Thus in the first section, discriminatory pricing in the ghetto is evaluated. In the second section, estimates are made of the impact of nonprice supply restrictions on the availability of owner-type housing to black households. The implications of the findings for the savings behavior of black consumers are explicitly considered. The third section considers the effects of market discrimination on the level and mix of the bundles of residential services consumed by black households.

The empirical analyses have been largely completed and one paper based on this research has been published.² A second paper has been submitted for publication, and we expect to complete soon a draft monograph reporting on the over-all study.

John F. Kain
John M. Quigley

THE NBER URBAN SIMULATION MODEL

During the past year the first version of our urban simulation model has been completed, and initial tests with it have been carried out. Although these tests demonstrated the computational feasibility and promise of the model's design, they also indicated that further calibration and re-estimation of portions of the model would be necessary before it could successfully replicate urban development patterns. We are now recalibrating the model on a data base whose suitability to the model's requirements should substantially reduce the problems discovered in our earlier tests.

² John F. Kain and John M. Quigley, "Measuring the Value of Housing Quality," *Journal of the American Statistical Association*, June 1970, pp. 532-548.

The simulation model represents the interaction of the housing market with the transportation system and the location of jobs in a metropolitan area. The model is recursive, and clears the market once each time-period by matching households seeking housing with vacancies in the stock. Households that seek housing are comprised of intrametropolitan movers, new households, and net immigrants. Vacancies in the stock are comprised of units vacated by movers, outmigrants, and defunct households, as well as new units. The market clearing mechanism produces an expected price for each type of house in each residence zone. These expected prices are subsequently used by both the supply and demand side of the market. The supply side uses the prices in determining the profitability of providing the various unit types in different zones, and in filtering existing units through three quality levels. The demand side incorporates the prices in demand functions that allocate households to the unit types.

The first version of the model made use of seventy-two classes of households working in nineteen areas of the city. These households chose their dwellings among twenty-seven types of housing units which were located in forty-four residence areas. Difficulties encountered in the initial tests of the model were mainly attributable to inadequate demand functions. The demand equations had been developed from a data base for the Detroit metropolitan area. This data base was a composite of several sources of information on house prices, house types, travel times between home and work, and family characteristics. Several strong assumptions were necessary for the use of this disparate information, and the estimated equations suffered accordingly. We are now recalibrating the model on a consistent data set for the Pittsburgh metropolitan area.

The computer program for the model's first version requires about twice the core storage available in the IBM 7094, but fits comfortably within the medium-size ranges of the IBM 360 series. The computer time required for a simulated year ranged from just over a minute on an IBM 360/91 to just over seven minutes on an IBM 360/67. Depending on the charge schedule of the computer center used, typical costs ranged from \$30 to \$80 per simulated year. However, the speed and low costs reflect advances in computer technology rather than model simplicity. If one assumed that no size constraint existed on the smaller computers, the IBM 7094 would have taken about three-quarters of an hour per simulated year, the IBM 7090 about four hours, and the IBM 709 about twenty-four hours. Thus, in the late 1950's this model would have cost approximately \$7,000 per simulated year.

The simulation model produces a considerable amount of information which is useful in evaluating various approaches to urban problems. The tested version of the model is capable of recording the impact of improvements in the street system or level of transit service upon the relocation patterns of households. It is one of the few models which even attempts to consider this effect, and the only one which handles the effect in such a direct fashion. The impacts of zoning ordinances and shifting employment concentrations are also observed in the simulation. In addition, demands for government services that relate to population numbers by small areas can be estimated. For instance, by using assumptions about the number of school-age children in each household class, the demand for school services in small areas can be estimated.

Although we are satisfied with its basic design, the model will undergo several modifications as the research effort proceeds. For example, the model being calibrated on the Pittsburgh data includes neighborhood quality as an additional characteristic of dwelling units; alterations to be incorporated in future versions of the model are a representation of racial or ethnic discrimination in the housing market and changes which will facilitate the simulation of programs such as rent subsidies and urban renewal.

Gregory K. Ingram
J. Royce Ginn

Prices for the different attributes of housing which comprise the bundle of residential housing services typically exhibit substantial spatial variation. An owner-occupied unit standardized for quality (age, number of rooms, lot size, and condition) in the central city may cost three times as much as an identical unit in the more distant suburbs. Spatial variation in the prices of particular quality attributes is also pronounced. This variation reflects the spatial distribution of jobs, the housing stock, and the transport system, all of which influence the nature of bidding in each geographic submarket. Households employed at different work sites therefore are confronted with a very different housing market, which in turn affects their housing consumption and length of work trip.

Individual household interviews on the attributes of housing consumed at each location and its price can be used to describe this spatial variation in housing prices. Together with data on family characteristics, income, location of work site, and residence, this provides the basis for estimating demand equations for the several types of housing services as related to income and prices.

The estimated demand equations for white households can be summarized as follows:

1. Households substitute a longer commuting trip for housing expenditures. Centrally employed households travel twice as far as households employed in the suburbs with similar socioeconomic characteristics. The former still pay 50 per cent more for comparable housing.

2. Centrally employed households also substitute other goods for housing consumption when faced with high prices for housing. Households employed downtown are more likely to acquire older housing, situated on smaller lots. Such households are also slightly less likely to be home owners, reflecting a greater steepness in the rent gradient for owner housing as opposed to rental housing.

3. Income and life-cycle characteristics are important variables in explaining housing consumption. In equations for probability of ownership and space consumption, the income elasticity is significant, though usually well below 0.5. Income has more significant effects on the choice of age of structure and lot size. The decision to acquire the largest lots is very income-elastic.

4. Price elasticities are generally significant, assuming values less than unity.

5. Substitution of quality attributes is quite responsive to relative prices; cross-elasticity terms are generally significant, and often exhibit elasticities well above unity. Households are quite prone to reject the very newest housing if they must pay any substantial premium over the price of housing which is ten years older. Conversely, lower-income households are reluctant to downgrade in terms of structure age unless the price premium for the newer units is quite large. The prices of near substitutes also exhibit high elasticities in the lot-size decision.

Subsequent research being conducted on the urban housing market is in two directions. First, housing choices by blacks are being examined. Due to housing market discrimination, the "rent surface" for blacks is not continuous. Black choices reflect two kinds of substitutions: different bundles of services consumed in a given ghetto area in the face of differing relative prices, and a different location in the event there are multiple submarkets open to blacks. Second order effects of black residential options on black employment opportunities and employment rates are also being examined.

These housing demand equations suggest several hypotheses about the role of housing markets in metropolitan development. In order to analyze such inferences, the supply side of the market must be more fully specified. This is the second research direction being examined. Of particular interest is the explanation for the spatial variation in prices of different bundles of housing services and decisions concerning new construction activity.

To date, analyses of the urban housing market have relied upon at least two unrealistic assumptions in deriving elegant, though oversimplified, results. First, the city is viewed as having a single employment location; thus, all locating households face monotonically increasing transport costs with respect to the same fixed point. Second, the housing "good" is viewed as an infinitely divisible commodity available or producible in any quantity anywhere in the urban area.

In fact, however, the dispersal of employment from the central business district is a well-documented phenomenon in most American cities. In addition, the dimensionality of housing has been addressed in recent research. The importance of a durable stock of fixed and differentiated housing bundles to the consumption patterns of urban households has nowhere been satisfactorily explored. Moreover, it can be shown that the introduction of durable stocks of housing is fatal to the simplified results of the classical formulation.

This study attempts to relax these restrictive assumptions about workplace, housing, and durable stocks using a random sample from all households in the Pittsburgh metropolitan area and a subsample of recent movers. From the larger sample of households and housing bundles, the location-specific prices of some eighteen types of rental housing are isolated. These housing types represent the joint purchase of housing density, over-all quality, and dwelling-unit size.

The analysis takes as given this spatially distributed set of market prices for these types of housing. It should be noted that for any type of housing, the set of prices may be smaller than the set of residential locations, indicating that the housing type cannot be purchased everywhere in the urban area. Employment location and income are also given exogenously, and the residential location problem is addressed for households that recently moved and whose employment locations are scattered throughout the urban area.

Under alternative assumptions about the value of commuting time, the gross price of housing (i.e., the rent plus journey-to-work costs) can be calculated for the stock of each housing type at each residential location for each household.

The first phase of this analysis is designed to test the hypothesis that households, in fact, minimize their gross expenditures for housing at alternative travel-time valuations. Preliminary results indicate that, at reasonable values of commuting time, more than half the households that consume a particular housing bundle do so within that 5 per cent of the housing stock where the gross price of the housing bundle is cheapest to them.

The second phase of the analysis will examine the decision to consume a particular housing bundle as a function of income, socioeconomic characteristics, and the minimum gross price.

The third phase of this project will examine those households that do not purchase the residential bundles where the prices are lowest to them. This examination will be conducted as a function of differentials in attributes of residential areas not included in the eighteen housing types. The differentials to be considered include alternative tax and public service bundles as well as differences in other measures of residential quality.

John M. Quigley

THE DEMAND MODEL: SPATIAL AND SOCIOECONOMIC DETERMINANTS OF HOUSING CONSUMPTION PATTERNS

In the *1970 Annual Report* I described the structure of a demand submodel being developed for the National Bureau Urban Simulation Model. My work in the past year has been concerned with further development of the analytical schema and with empirical testing of the basic workplace-housing consumption hypothesis.

The primary conception is one of a housing market decomposable into a finite set of submarkets differentiated by major characteristics of the housing consumption bundle, e.g., lot size, housing quality, neighborhood quality, house room. The

model has been given spatial content through the recognition of alternative vantage points from which individual households view the housing opportunity surface. The essential components of the model are the workplace, which determines the vantage point from which housing opportunities are surveyed, the distribution of the various components of the housing stock in space, and the transportation system that links the workplace to the distribution of the housing stock. Changes in the spatial distribution of the labor force serve to alter the over-all patterns of housing demand, given the existing transportation system, and, through the stock adjustment process, lead to dynamic modifications in the standing stock of housing.

While the objective has been to provide a spatial conception of the housing market and of housing demand, it has not been necessary to slight the more conventionally stressed elements in housing consumption choice, in particular family characteristics and life cycle. In fact, a major test of the model is the degree to which these elements of demand are clearly represented; the observed income, education, and family-size effects on housing consumption choices are clearly representative of the key family status elements of the housing choice process. Even in these dimensions of housing consumption choice, however, the approach embodied in this model serves to demonstrate the processes of substitution which are operative in household choices. By identifying discrete and disaggregated substitutions in the various dimensions, the model demonstrates the full range of effects associated with family characteristic variations.

But the major purpose of the model is to isolate the spatial components of housing consumption choice: The observed pattern of workplace-specific variation in housing consumption clearly demonstrates that household choices are conditioned by objective circumstances that define and constrain the household's view of housing alternatives. The key fact of urban structure, its nonhomogeneity and its differentiated spatial aspect, is represented by the workplace variations in housing consumption patterns; this spatial heterogeneity significantly modifies individual behavior.

A number of difficulties have been encountered in the analysis, particularly the inadequacies of small-area price data. Also, the application of the model to date has ignored a number of significant aspects of the housing market. A notable example is the dimension of "neighborhood characteristics," e.g., public service quality. Elizabeth Pinkston has examined some evidence of variations in public school test scores which suggest high collinearity with other neighborhood population characteristics, such as adult educational attainment, but these factors require significantly more analysis.

The failure to incorporate the racial dimension of urban spatial processes is the major restriction of the present application of the model. An effort will be made to examine differences between actual black housing consumption and the housing patterns which would be predicted on the basis of the white equations. This effectively involves determining the sources of the difference between black and white behavior: Is the adverse housing consumption experience of blacks due to basically different patterns of consumption even when the housing opportunity is viewed from the same vantage point (workplace), or is the major source of white-black difference to be found in the concentration of employment opportunities for blacks in areas adversely orienting housing consumption choices? The answer to this question would provide a significant addition to knowledge even though it is probable that potentially inhibitory workplace distributions are the result of prior restrictions on housing consumption choice. Even given uncertainty as to the sources and directions of causality, it is possible that the historical causes of such a phenomenon have very little relevance to the design of public policy. Past causality creates the environment of current change but does not necessarily determine current alternatives and options.

Stephen P. Dresch

A draft embodying the results of my research on housing demands has been submitted to a staff reading committee for possible publication as a National Bureau monograph. The objective of the research was to examine the demand for housing in the short run. The research was based on a general model in which the expected quantity of housing services demanded by a household in a market transaction (during a specified period) is the resultant of a multiplicative relation between two functions. The first may be a conventional demand function, but is conditional upon entry into the housing market. Empirical research upon this portion of the model dealt with appropriate measures of income, including life-cycle influences, and with problems connected with aggregation. The second function is a predictor of the probability of the household entering the housing market by moving its residence during the period. Variations in the influence of the gap between desired and actual levels of housing consumption by stage in the life cycle were examined.

In particular, an attempt was made to compare the explanatory power of several measures of income in demand equations estimated upon observations of a large group of households which had moved during the one-year period prior to the date of the survey. It was found that current income generally yields a better fit than does a measure of the permanent component of income defined by the household's occupation, industry, and level of education of the head. However, a more dynamic formulation of the permanent income variable, which is assumed to represent the effects of the asset level, yields a better explanation than does current income. The permanent and transitory components of total income are found to have significantly different effects upon the level of housing purchased or rented, with a much lower elasticity with respect to the transitory component. Both current and permanent income measures display elasticities well below 1.0, generally in the range of .35 to .65, whereas other studies, based primarily upon aggregate data, claim to demonstrate much higher elasticities.

The sample of movers was examined with respect to the stability of the parameters of the demand equation under disaggregation. The results, in general, indicate heterogeneity. This heterogeneity is believed to stem only in part from underlying differences among the subgroups defined for the analysis. It is felt that, in addition, imbalances between market value and the real flow of services from a housing unit may also be important in explaining this heterogeneity.

In the empirical work dealing with the rate of residential mobility, the total sample, which includes both movers and nonmovers, was divided into eight groups according to tenure type (ownership or rental), age of head and, to represent taste for moving, years since the prior residential move. For regressions run on representative cell values within each group, parameter estimates were insignificant in most cases; however, some tentative comparisons could be made. The influence of a gap between desired and actual housing consumption appears to be more important, relative to the influence of family-size change and accessibility among young households than it is later in life. A positive gap in housing consumption (where the desired level exceeds the actual level) appears to be more effective in the decision to move than is a negative gap of the same size, at least among renters, for young and middle-aged household heads. The result is consistent with the assertion made in the study that households tend to resist reductions in their housing consumption. For young owners with short tenures, the greater influence of a negative gap may be attributed to wealth considerations; for households in the oldest age brackets, the near equality of influences which was observed might be explained by unobserved reductions in household size.

Irving R. Silver

INTRAMETROPOLITAN WORKPLACE LOCATION

Our preliminary research on the patterns of change in location of manufacturing

activity within intrametropolitan areas has been completed, and our report is forthcoming. The importance of the location of manufacturing employment for a wide range of metropolitan circumstances hardly needs emphasis. Past efforts expended on examining these patterns, though great, have been hampered by lack of data. Our study employs a unique data set which allowed both time-series and cohort analysis. This data set was described in last year's *Annual Report*.

We sought to examine, on a geographically and industrially disaggregated basis, the change in the location of manufacturing in the Boston, Cleveland, Minneapolis-St. Paul, and Phoenix metropolitan areas over the 1965-68 period. In addition, we examined the processes by which these changes were produced (establishment relocation, establishment growth and decline, and the birth and death of establishments). Both the changes and the processes producing them were employed in a simple examination of the hypothesis that concentrations—"agglomerations"—of activity of an industry in a geographical area appear to result in significant net external economies for establishments in the industry.

The most striking result of our research has been the uniformly high degree of industrial mobility observed over a relatively short time period. Aggregates of movement, birth, and death in the areas studied amounted to 37 per cent of total establishments in the areas in 1965 and 17 per cent of total employment. This high degree of mobility of establishment accomplished an unexpected degree of change in the geographic distribution of industries. Location change expressed as a per cent of base period activity ranged from 7 per cent in Cleveland to over 20 per cent in Phoenix.

The geographic distribution of the processes which produced these location changes is very interesting. Considering first the relocation effect, core areas within the SMSA's consistently experienced net out-migration of establishments. In Boston, Cleveland, and Minneapolis-St. Paul, only four of the twenty-five analysis zones within the four central cities experienced net in-migration of moving establishments in terms of employment. In Phoenix, core areas within the large central city experienced out-migration. This pattern of net migration is produced to a large extent by the apparent aversion of moving establishments to core area locations. Rates of gross out-movement were not substantially different between core and suburban zones.

Employment in new establishments was distributed in gross terms quite similarly to the distribution of the destinations of moving establishments. Rates of birth of establishments and of their employment were consistently higher in suburban zones than in core areas. This finding certainly weakens the hypothesis that new establishments are attracted to core areas by the availability of rentable space and other factors that they are unable to provide themselves internally.

Very little systematic variance in the rates of employment death within metropolitan areas was discovered.

Eight zones in the central cities of Boston, Cleveland, and Minneapolis-St. Paul experienced growth in employment levels, although the sum of the employment of defunct and out-moving establishments exceeded that of new and in-moving establishments. Employment grew in these zones as a result of substantial growth of existing establishments. The explanation of this phenomenon is elusive. It may be a result of demand pressures accompanying the high level of cyclical activity during the study period; it may also suggest the availability of internal economies to core-area establishments which can to some extent insulate them from an apparently less than optimal location. Our analysis of the behavior of concentrated and nonconcentrated industries suggests that agglomeration economies may act relatively powerfully to preserve the concentrations of activity which produce them.

Raymond J. Struyk
Franklin J. James, Jr.

Since last year's report, I have completed a substantial portion of my research and plan to organize my findings soon into a monograph. A short summary of some of my results follows.

Cyclical instability of unemployment appears to be associated most strongly with two variables, the industrial composition of employment and human capital. Large differences in the cyclical sensitivity of unemployment among states imply, among other things, that the full-employment policy often advocated for eliminating poverty may have stronger effects on states with greater cyclical sensitivity. These states, however, are not necessarily the ones with larger percentages of families living below the poverty line (\$3,000). Moreover, the decomposition of variances in cross-sectional unemployment suggests that differences among states in unemployment reflect cyclical differences to a greater degree during the downturn than during the upturn of the cycle. "Depressed" areas would be more accurately identified by unemployment rates during periods other than recessions.

Seasonal fluctuations vary among states. The industrial composition and the degree of industrial diversification have the strongest explanatory power on seasonal fluctuations in unemployment.

One of the findings in the analysis of levels and trends is the apparent existence of a force equalizing the unemployment rate among states. States with high unemployment experienced a decrease, and states with low unemployment an increase, in unemployment between 1950 and 1960. Such an equalizing force may be the result of movements of capital into and of labor out of high unemployment states, induced by differential rates of return to capital and wage rates. Although this hypothesis is being examined further, it is supported by such findings as a greater net out-migration of labor, a higher rate of economic growth, and slower rates of population and labor-force growth in states with higher unemployment.

Additional research on cross-sectional unemployment by industry, age, sex, color, education, and skill level, as well as an analysis of weeks worked, is in progress. Census data are being used for this study. Its purpose is to arrive at an estimate of the residual variation in the unemployment rate and weeks worked, after standardizing them by the factors mentioned above.

Masanori Hashimoto

GHETTO EMPLOYMENT PROBLEMS

During the past year I have completed most of the first stage of my research on ghetto employment problems in the United States, proceeding on both the theoretical and the empirical levels.

On the theoretical level, I have tried to summarize and formalize certain trends in the economic analysis of these problems, which began to emerge during the 1960's. Three separate models can be identified. Orthodox economists, first of all, sought to revise and apply orthodox economic theory to explain some of the instability and poverty so commonly found in ghetto labor markets. A "dual labor market" theory and model also developed during the decade, expanding and modifying orthodox theory in an attempt to explain an apparent "dichotomization" of the labor market. Finally, radical economists sought to interpret the phenomena of the ghetto labor market by applying some general hypotheses from a newly evolving radical economics.

In my theoretical work, I have tried to clarify the explanations of ghetto employment problems suggested by these different groups of economists and to formalize the links between their analyses of these problems and the broader models of income determination and distribution upon which these analyses depend. I have compared the empirical expectations of each group regarding urban employment and income behavior patterns and have surveyed some of the empirical evidence on the main issues dividing the theories.

Most of this analysis is included in a manuscript, currently under revision,

called "Economic Theories of Poverty and Underemployment." In this draft I argue that economists differ most widely about three central questions. First, they differ in their approach to labor market stratification—the ways in which the labor market may be segmented and in which workers in different strata tend to behave. Second, they seem to differ in their analyses of the historical sources of job definition and job structure. Third, they differ in their attitudes about the concept of economic "class."

In my empirical work, I have finished a first round of detailed analysis of the first of these three questions. In endeavoring to test for the presence and importance of labor market stratification, I have made use of an immensely interesting body of data from the first year of the U.S. Urban Employment Survey, conducted in 1968-69. I have studied two samples from that survey, one from the central city of Detroit and the other from the three principal black ghettos in New York City. I have been testing what I have called the Structural Stratification Hypothesis. According to that hypothesis, formalized in both the dual market and the radical models, labor markets are so stratified in the United States that labor market behavior and attitudes differ fundamentally among workers in the different strata.

My exploration seems to provide fairly consistent empirical evidence supporting this Structural Stratification Hypothesis in two different ways. One involves a comparison of the determinants of labor market career patterns among different demographically defined groups of workers, stratified principally by race, sex, and age. This comparison suggests that most disadvantaged groups of workers are less successful than other groups in capturing returns from self-investment during their careers—investments like education, on-the-job training, and work stability. The second test of the hypothesis, using factor analysis, provides some interesting evidence that jobs in the labor market are dichotomously and discontinuously divided into different sectors, which I have labeled the primary and secondary sectors. Separating the workers in my samples into these two empirically defined sectors, I find that the behavioral differences which I had identified among demographically defined groups of workers may be largely explained by the sector in which the different workers find employment. Those blacks who are fortunate enough to find work in the primary sector, for instance, appear to be able to realize returns to variables reflecting individual self-investment. On the other hand, both blacks *and* whites with jobs in the secondary sector seem largely unable to realize returns to their self-investment.

These results, though tentative, suggest the importance of concentrating labor market analysis on the determinants of the distribution of employment opportunities and of workers between the two sectors.

On the second and third questions noted earlier, I have begun a survey of the economic literature on the history and process of the progressive specialization of labor and the progressive importance of job hierarchies. With others, I have also begun to try to revise and formalize the radical definition of economic class, through a general theory of labor market stratification.

David M. Gordon

3. HUMAN RESOURCES AND SOCIAL INSTITUTIONS

EDUCATION AND OTHER STUDIES ON HUMAN CAPITAL

Introduction

The series of studies being financed by the Carnegie Commission on The Future of Higher Education are nearing completion. In manuscript form are two studies by Paul Taubman and Terence Wales, one on educational attainment and mental ability, the other on education as an investment and a screening device. A collection of essays on the economic benefits of education is well along, with most contributions now in manuscript form. The volume will include studies by: Robert Michael, "Education and Fertility" and "Education and Consumption"; Jacob Mincer, "Education, Experience, and the Distribution of Earnings and of Employment"; Isaac Ehrlich, "Educational Attainment and Participation in Illegal Activities"; John Hause, "Ability and Schooling as Determinants of Lifetime Earnings, or If You're So Smart, Why Aren't You Rich?"; Gilbert Ghez, "Lifetime Consumption Patterns and Wage Rates"; Taubman and Wales (summaries of the two manuscripts mentioned above); Lewis Solmon, "The Relationship Between Schooling and Savings Behavior: An Example of the Indirect Effects of Education"; Sherwin Rosen, "Knowledge, Obsolescence and Income"; Albert Beaton, "Educational Attainment and Socioeconomic Attitudes"; and an introduction and summary by F. Thomas Juster. The essays by Solmon and Rosen represent summary versions of studies that are expected to be published subsequently as independent monographs.

Another collection of studies under the direction of Gary Becker is also close to completion. Papers by Becker, Jacob Mincer, and Barry Chiswick have been reviewed by the staff reading committee and are now undergoing revision. The focus of these studies is on the contribution of investment in human capital to an explanation of the distribution of income and earnings. These studies are reported below.

During the past year we have continued to expand the content of the NBER-TH sample of Air Force veterans. As a result of additional attempts to locate respondents, we were able to obtain an additional 650 or so responses, bringing the total to just under 5,100. In addition, along with a summary of results from the survey, we sent out a brief supplemental questionnaire designed to fill in some important gaps in the data file. Some 3,500 returns were received out of 5,100 questionnaires mailed.

Our research agenda is centered around a fuller exploitation of the potential in the NBER-TH sample for analysis of earnings functions, occupational selection and mobility, nonmarket behavior, the intergenerational transmission of human capital investments, and the returns to schooling and ability at the upper and lower ends of the income distribution.

With this in mind, we have submitted research proposals to the National Center for Educational Research and Development, focused on the returns to differences in educational quality and on analysis of nonmarket behavior, and to the National Science Foundation for an analysis of the determinants of the distribution of income and earnings. We have also been discussing with the Office of Economic Opportunity prospective research on poverty and the structure of labor markets.

The central theme of this research program is the notion that productivity and earnings are functionally related to the stock of human capital, and that human capital itself is a product of the quantity and quality of formal schooling, learning opportunities associated with the job market, innate ability, and preschool investment in children by parents.

F. Thomas Juster

Human Capital Analysis of Personal Income Distribution

Following the review by a staff reading committee, I am preparing a final draft of

my manuscript "Schooling, Age, and Earnings." The findings were described in the *1970 Annual Report*. To repeat briefly, the evidence shows that the distribution of annual earnings of males is associated mainly with the distribution of their accumulated human capital investments. This relation is expressed in a human capital earnings function, derived from human capital theory, and relates logarithms of earnings to years of schooling and of labor force experience. The function can explain as much as two-thirds of earnings inequality observed among U.S. males of preretirement ages, using individual earnings data from the 1960 Census.

Barry Chiswick, Carl Rahm, Michael Tannen, and myself are proceeding with further applications of the human capital earnings function to analyses of (a) regional differences in earnings and in earnings inequality (see Chiswick's report below), (b) changes in income inequality in the United States since 1939, and (c) levels and changes in the occupational structure of earnings, that is, "skill differentials" in earnings. One of the findings, by Rahm, is that the human capital earnings function explained over 75 per cent of the relative skill differentials in earnings of close to 500 male occupations in the United States in 1959. The implicit rate of return on the schooling component of occupational investment was in the range of 11-16 per cent.

The analyses of earnings distributions reveal that the more educated and experienced workers have larger annual earnings, not only because their wage rates are higher but also because they spend more time in gainful employment during the year.

My next research task is the study of the distribution of employment as a component of the distribution of earnings. This study will be a continuation of my past work on the composition of the labor force and of unemployment. A start on one aspect of this new work is made in a joint study with Masanori Hashimoto on the effects of changes in minimum wages, on which a preliminary report was given at the Econometric Society meetings in Detroit. That study is described immediately below.

Jacob Mincer

Employment and Unemployment Effects of Minimum Wages

The effects of minimum wage changes on unemployment involves more than a knowledge of the employment effects with which most studies have been concerned. Labor force effects on the supply side, together with the employment effects on the demand side, determine the unemployment effects. We extend the usual analysis of demand to incorporate supply responses. Given an increase in minimum wages, labor supply to the sector may increase or diminish in the short run depending on whether the wage gain or the decreased probability of employment dominates in worker responses. If supply increases, generated unemployment exceeds disemployment; otherwise the unemployment effects are smaller than the employment effects. Given a once-for-all minimum wage increase, what matters in the long run is the sectoral employment effect, since unemployment will be diffused by mobility and otherwise determined by aggregate conditions. If minimum wage hikes are frequently repeated, however, the short-run effects can be important in the observed distributions of unemployment.

The theoretical model describes the labor market for a given class of labor as consisting of three relationships: (1) demand: $D = D(w)$: $\delta D / \delta w < 0$; (2) supply: $S = S(w, p)$ where w is the wage rate and p is the probability of obtaining employment: $\delta S / \delta w > 0$, $\delta S / \delta p > 0$; (3) probability: $p = f(D/S)$. The short-run minimum wage effects on demand, supply, and unemployment are derived from these relationships for empirical study.

The empirical analysis further distinguishes between immediate and longer-term responses. The longer-term responses on the demand side represent substitution of capital and of related labor for the particular labor group. On the supply side information gained by search activity eventually redistributes labor away

from the affected sector, or reduces labor force participation. The Almon-type distributed lag technique is one of the tools used to identify the time-shape of responses to minimum wages, as well as the total effects.

Our findings suggest that (1) there are significant minimum wage effects on employment and labor force participation rate of teenagers and males aged 20-24; (2) the labor force participation effects are predominantly negative; (3) both disemployment and labor force effects are greater for nonwhite than for white groups; and (4) there is a large unemployment effect for nonwhite teenagers and nonwhite males aged 20-24.

Masanori Hashimoto
Jacob Mincer

Interstate Analysis of the Distribution of Income

The purpose of this study is to provide a statistical explanation of interstate differences in the level and relative inequality of labor market income for white and nonwhite males. In an earlier study, a simple investment-in-schooling model was used to generate an earnings function, which was found to explain up to 60 per cent of interstate differences in income inequality.¹ In this study the earnings function is expanded to include the effects of labor market experience, weeks worked, and race.

By taking the variance of both sides of the earnings function, the relative inequality of income is expressed as a function of the average rate of return from schooling, the level and inequality of years of schooling and of years of experience, and the relative inequality of weeks worked. Preliminary analyses for all males and white males alone indicate that the independent variables can explain (adjusted R^2) approximately 80 per cent of interstate variations in relative income inequality: North-South differences in inequality are reduced by three-fourths. The most important explanatory variable is the rate of return, followed by relative inequality of weeks worked, the distribution of experience, and the distribution of schooling. An analysis of income inequality among nonwhites is in progress.

Differences in the level of income are analyzed by relating the average level of the log of income (i.e., the log of the geometric mean) to the rate of return from schooling, and the levels of schooling, experience, and weeks worked. The empirical analysis is still in the preliminary stage. Differences in the ratio of nonwhite to white incomes will also be examined, using the ratio of the respective earnings functions.

Barry R. Chiswick

Economic Growth and the Distribution of Labor Income

This study applies insights obtained from modern growth theory to the human capital approach to the distribution of labor income. The objective is to explain secular changes in income inequality and skewness.

The basic equation for income inequality, using human capital concepts, is:

$$\text{Var}(\text{Ln}Y) = \bar{H} \text{Var}(r_{ij}) + \bar{r} \text{Var}(H_{ij}) + \text{Var}(H_{ij}) \text{Var}(r_{ij})$$
where Y is labor income, r_{ij} is the rate of return to the i^{th} individual on the j^{th} investment in human capital, H_{ij} is the size of the j^{th} investment in human capital undertaken by the i^{th} individual measured in units of cost, and \bar{r} and \bar{H} refer to the respective averages. Skewness (concentration) can be shown to vary in the same direction as inequality.

A theoretical model that formalizes the effects of the growth process on the distribution of labor income has been completed, though not all the implications of the model have as yet been tested. One major untested implication, which is in direct conflict with the conclusions of a number of previous studies (e.g., Aigner and Heins, Al-Samarrie and Miller, both in *AER*, March 1967), is that the more

¹ See B. R. Chiswick, "Interregional Analysis of Income Distribution," in "Human Capital and the Personal Distribution of Income," proposed NBER study.

physical-capital intensity in a region, other things being equal, the greater the inequality and concentration of labor income in that region. This implication follows from the empirical findings of Griliches (*RESTAT*, August 1969) and others, which show that physical capital is more complementary with skilled than unskilled labor. Hence, a region with a high physical-capital intensity would be one with a large divergence between skilled and unskilled wage rates, other things being equal, and thus one with a high rate of return to human capital. From the equation, we see that this would lead to greater inequality (and hence concentration) of labor income.

One might argue that this conclusion is trivial, since it hinges on the *ceteris paribus* specification. As barriers to investment in human capital are reduced over time, or as migration of skilled labor takes place, it is likely that this high rate of return will be driven down. If so, however, it follows that the average level of human capital in the region would rise (as might the variance in levels of human capital), and, from the equation, the consequence would be greater inequality of labor income. This analysis suggests a second major implication (an important special case of which was pointed out by Chiswick, *AER*, June 1968), that the more skill-intensive a region, other things being equal, the greater the inequality in labor incomes. The possible offsetting effects of a reduction in the rate of return can be analyzed in a fashion similar to that above.

For the empirical analysis, the stock of human capital is approximated by levels of schooling. Work on measuring secular changes in the distributions of schooling and labor income on a national, regional, and statewide level (using published U.S. census data) is nearing completion. Preliminary results indicate that the inequality in the distribution of labor income by states has continued to narrow over the period 1940-60 despite rising levels of education and a widening of the distribution of schooling. But from 1950-60, the data reveal that this narrowing occurred while the dispersion of personal incomes for the states increased. Thus we might tentatively conclude that while labor income may well be the single most important component of the personal income distribution, the reduction in its dispersion has not, at least from 1950-60, been sufficient to offset the increasing dispersion of other components of the distribution.

Michael Tannen

The Allocation of Consumption and Time Over the Life Cycle

Since last year's *Annual Report*, further tests of the model have been performed with more refined measures of consumption and earnings than those used previously. In particular, an estimate of the service yielded by owned dwelling has been computed by age of the household head, and this measure is included in the aggregate consumption variable. A manuscript is now being prepared for publication, incorporating both the results of the project and those of Gary Becker on hours of work over the life cycle.

Gilbert R. Ghez

Education and Fertility

Both casual observation and more systematic empirical findings suggest that the simple relationship between a couple's level of education and its number of children is negative. This research project asks the question, Does this negative relationship continue to exist when the couple's age, income, and time value are held constant? A model is developed in which two explanations for a separate, direct effect of education are explored.

The model employs the framework of household production functions in which there exists a demand for child services and a derived demand for children. By emphasizing the joint-production aspects of nonmarket production it is shown that, since the cost of avoiding children is positive, the household may effectively demand more children than it "desires." Thus, factors which reduce the costs of

preventing children, or lower the cost of contraception, will tend to reduce the quantity of children demanded.

Education is viewed as having its effect on family size through the efficiency with which parents prevent unwanted births and also through the efficiency with which they obtain child services from children. If increases in the level of education raise proficiency in both respects, it is shown that the quantity of children demanded will be negatively related to the couple's education level, since both the desired number of children and the discrepancy between desired and effectively demanded quantity of children will be reduced.

The empirical work completed to date utilizes the first wave of the NBER-Census Bureau Consumer Anticipations Survey (taken in 1968). The sample is not representative of the U.S. population; it covers a relatively high-income, well-educated suburban group of about 4,000 households. The data are used to explore the relationship between the number of children in the household and family income, the value of husband's and wife's time, their age and education level.

The results suggest that the partial effect of education on the number of children is negative. More educated couples also appear (other things held constant) to space their children more evenly and closer together on the average. However, these effects do not appear to be independent of the age at which the wife begins childbearing, which is itself positively correlated with her education level. An effort will be made to explore the relationship between the economic variables and the age at which childbearing begins, in order to distinguish a difference in the age at marriage from a difference in the time interval between marriage and the first birth. Additional work will also attempt to separate the effects of education on contraceptive proficiency from its effects on desired family size.

Robert T. Michael

Higher Education as an Investment and as a Screening Device

The primary questions examined in our study are: What is the rate of return to an investment in higher education at various ability levels? How large a bias is there when ability is omitted in studying the rate of return to higher education? Is education used to screen people out of occupations in which they could have earned more if allowed to enter? In order to answer these questions, we have extensively examined a sample drawn from the men who were in the Army Air Force pilot, navigator, and bombardier program in 1943. A random sample of 10,000 men responded to a questionnaire survey conducted in 1955 by Thorndike and Hagen. In 1969 the NBER resurveyed these 10,000 and, by the time our analysis began, some 4,500 people had responded. While these responders are the brighter and better educated of the 10,000, there is no success bias in the responding group. Approximately one quarter fell in each of the categories: a high school degree, some college, a college degree, and various stages of graduate school. On the basis of factor analysis conducted on seventeen tests administered in 1943, it is possible to identify four types of ability—quantitative, physical coordination, IQ, and spatial perception.

We used regression analysis with separate dummy variables for each education level and each fifth of the various ability measures. The equations also include variables for age, health, marital status, and family background. We tested for interactions between education and ability (and other variables) by computing separate equations for each education class. In 1955, when the respondents were about thirty-three years old (and most of those who had attended college had been working less than ten years), there was no evidence of an interaction between ability and education. Among the ability measures, only quantitative skills appear to be a significant determinant of earnings. This type of ability, whose effect is about linear, appears to be as important for high school graduates as for Ph.D.'s. Moreover, when measured by its influence on the range of the earnings distribution, ability was more important than education in 1955. For 1969 we obtained approxi-

mately the same results, with the exceptions that (1) the effect of ability on earnings is stronger for those who attended graduate school than for others; (2) the effect of ability is linear until the top fifth of the distribution is reached, and then a much larger increase in earnings appear; (3) the range of earnings due to ability (classified by fifths) is about as large as the difference between high school and some college. Somewhat cruder analysis indicates that in 1946-48 there was no effect of ability on initial job earnings within the various education cells.

After standardizing by ability and the other personal characteristics given above, we found earnings differentials as shown in Table II-2. In 1955, the differential between high school graduates and other education classes is about 10 to 15 per cent for most categories. By 1969, the differentials are higher and tend to rise with education.

Using the data in Table II-2, as well as various interpolation and extrapolation devices and information on foregone earnings and average per student expenditure on higher education, we calculate that the actual (ex post) social rate of return to some college education is 14 per cent while that for a B.A. or B.S. degree is

TABLE II-2

Extra Income from Education for the Average High School Graduate

Education	Percentage Increases in	
	1955	1969
Some college	11	17
Undergraduate degree ^a	12	31
Some graduate ^a	15	26
M.A. ^a	10	32
Ph.D.	2	27
M.D.	72	106
LLB	19	84

^a For those who do not teach in elementary or high school.

about 11 per cent. When we deflate the age-earnings profiles by the CPI, these rates are reduced 3 percentage points. In this sample, which is drawn from the top half of the earnings distribution, the rate of return to education is the same at each ability level because foregone earnings do not depend on ability and because earnings and ability do not interact subsequently. The rate of return to some college is greater than for an undergraduate degree partly because a large percentage of business owners fall in this category, and their earnings include a return to financial investment as well as to risk. After adjusting for business owners, the rate of return to some college is slightly greater than for an undergraduate degree.

The bias caused by the omission of ability in calculating the rate of return to education is about 30 per cent in 1955 and 20 per cent in 1969; the results vary by education level. When ability and all other noneducation determinants of income are omitted, the bias is about 35 per cent. When the 1946 and 1949 Current Population Reports and Census income differentials by education are adjusted for such biases, expected rates of return are about the same as the ex post returns for B.A. holders. For those with some college, expected returns based on 1946 data are about the same as ex post returns, but 1949 data show smaller expected returns for this group.

If there were free entry into each occupation, and if we ignore certain problems connected with nonpecuniary returns, occupational choice would be based on (lifetime) earnings in the various occupations. On the basis of regressions which include education, ability, and other personal characteristic variables, we can calculate the expected earnings by education in occupation categories: profes-

sional, technical, owner-managerial, sales, white collar, blue collar, and service. For each occupation and educational level, we assume that the distribution about these expected earnings functions would be the same as for people with the same ability and other characteristics. We assume that the distribution is normal, and calculate the variance from residuals in each of the within-occupation regressions.

The results indicate that, at the high school and, to a lesser extent, at the same college level, there are more people than predicted in the low-paying white collar, blue collar, and service occupations. If the within-occupation income differentials by age group are added up, with the weights being the number of people indicated by our free entry model, the over-all income differentials by education would decline by one-half to two-thirds.

Paul Taubman
Terence Wales

Knowledge and Income

The objectives of this research are to construct and estimate models explaining the accumulation of knowledge over an individual's lifetime, along with the corresponding profile of lifetime income. The problem may be approached in terms of the optimal rate of accumulation over the lifetime. If learning is available only at increasing marginal cost, individuals should transfer learning activities to the labor market after some point, thus distributing learning costs over time. Only in this way can lifetime income be maximized. The model thus incorporates learning-by-experience into decision-making.

Following Becker's important analysis, two types of knowledge may be determined.

Firm-Specific. Some knowledge may have use only to particular firms and not to others. In effect, this is the case for entrepreneurial capacity. Decision-makers are not only "born," but "made." Learning-by-doing suggests that the accumulation of such knowledge is in part a by-product of the productive process itself. Hence, firm-specific knowledge may be regarded as a factor of production in a production function that includes two outputs: marketable goods of the usual sort and additions to firm-specific capital, or learning. I have drafted one paper entitled "Learning-by-Experience as Joint Production," which considers optimum accumulation in the simplest by-products cases. It is shown that even though learning is an automatic consequence of production, it will generally pay the firm to forego short-run profit and expand its operations in order to learn more than would be implied from maximizing profit alone.

This proposition has a number of implications for long- and short-run firm behavior. In particular, the model implies a birth-death process and internal economies for firms, very much in the spirit of Marshall's analysis of the evolution of firms. It also has implications for cost-plus contracting and the phenomena of progress of "learning" functions, which relate productivity to previous outputs or inputs.

General Knowledge. Knowledge may be transferable and have market value in a wide variety of firms. In these cases, firms again produce marketable outputs as well as learning, but now must be regarded as *selling* the latter to employees. Since learning is connected with the nature of jobs, workers will in effect pay the costs of learning through the emergence of a set of equalizing wage differences. Jobs offering greater opportunities to learn offer lower net wages (given the worker's skill) than those offering lesser opportunities. Workers maximize lifetime wealth by choosing a sequence of jobs with different learning content at different points in their working life. This process describes the evolution of embodied knowledge and *explains* age-income profiles. It also naturally leads to a theory of occupational mobility.

Some very simple models along these lines are discussed in my paper "Learning and Experience in the Labor Market," which applies the analysis to the problem

of occupational discrimination against minority groups. A more complete treatment of the problem is found in "Knowledge, Obsolescence, and Income," which represents my contribution to the Carnegie volume. In this paper, the model is used to obtain a priori restrictions on age-income generating functions, which are then estimated for white male college and high school graduates based on 1959 income data. The parameters of these functions can be identified with rates of obsolescence and depreciation on human capital, or on various vintages of schooling achieved at different points of time, as well as with certain ability factors and rates of interest. There is some evidence to support the notion that knowledge possessed by college graduates depreciates at a more rapid rate than that for high school graduates, but that college graduates possess sufficiently greater "ability" to more than overcome these differences. These findings have implication for the role higher education plays in making recipients adapt more easily to changing circumstances, and possibly for the role formal education plays as a certification device in the labor market.

Sherwin Rosen

**The Relationship Between Schooling and Savings Behavior:
An Example of the Indirect Effects of Education**

This study investigates whether differences in schooling attainment are systematically associated with differences in savings attitudes or savings behavior.

The data used are from surveys of members of the Consumers Union, taken between 1957 and 1959. These surveys contain information on current income and income history of the family and its members, and details of financial asset holdings at the end of 1958 and at the end of 1959. From the asset data, 1959 savings can be calculated. Other available measures include education of the family head, socioeconomic characteristics of the families, attitudes toward savings-related issues, and consumer durable purchases, including housing and automobiles. The basic sample contains over 3,300 observations (families): a substantial number of cases were eliminated because of missing data, questionable or inaccurate reporting, etc.

Saving is defined as the change in financial and nonhousing property assets minus the change in nonhousing debt. A dummy variable is used to control for the fact that some family heads were business proprietors or independent professionals, and hence might have saved by acquiring business assets. Estimates of post-school investment in human capital were added to both saving and income for some of the calculations.

The actual savings behavior of families in our sample was studied in a number of ways. First, separate savings functions were estimated for each of four education subgroups in the sample; that is, a savings function was estimated for all families whose head had high school education or less, four years of college, etc. A second approach was to combine all families in estimating a single savings function which included an interaction term between income and education level.

Besides family income after taxes, explanatory variables included wife's income, unrealized capital gains, a self-employment dummy, and certain components of savings (like consumer durables) not included in the dependent variable. In general the regression results tend to confirm the view that the more educated have greater savings, whether greater is defined as a ratio to income, an elasticity, or a marginal propensity to save. This conclusion holds for alternative definitions of savings. Some of the results are summarized in the table on p. 104.

Saving represents provision for the future; and so, greater saving implies greater provision for consumption in old age and for future generations, and also greater potential capital formation for future income. Hence we may infer that as the educational attainment of our society grows, we shall benefit from the added future wealth, security and growth made possible by these increased savings propensities.

Savings	High School or Less	Some College	Four Years of College	More than Four Years of College
Financial and nonhousing property	.0564	.0700	.0966	.1169
As above plus on-the-job train- ing and mortgage repayment	.0793	.1178	.1748	.2019

The survey also contains indirect measures of time preference, liquidity preference, risk preference, and efficiency in saving. These data were studied both by examining simple classification of families and by regression analysis. For each education group the proportion selecting various responses to these attitude questions was calculated, and systematic patterns by education emerged. In almost all of the regressions, the effect of education was significant in the expected direction, despite significant effects of other factors.

Some indirect benefits of a more educated populace can be inferred from my results. These include an economy more willing to defer consumption to obtain future growth, more willing to take risks, and more willing to put assets to productive uses.

The complete study is now in manuscript form, although a few additional tests need to be conducted.

Lewis C. Solmon

Information, Education, and Productivity

For the past few years, one of my major research objectives has been to understand and empirically identify the role of education in consumption and production. The thrust on a theoretical level has been to identify the product of an intangible, like education, whose main function may be that of affecting "efficiency" in using other factors. The idea is that, in a world of uncertainty, *ex post* mistakes occur because some decisions must be made with incomplete information. To the omnipresent second-order approximation, the "expected" costs of these mistakes can be expressed as fairly simple functions of error variances in first-order optimizing conditions. Education is then seen as a means of reducing these error variances. These ideas are developed in a paper on the value of information, which should be available shortly.

In a draft manuscript on "Returns to Scale in U.S. Agriculture," I offer support for the hypothesis that education's major function may be that of enhancing learning capacities or simply of processing information.

Two empirical facts of life are: (1) agricultural production-function estimates show increasing returns to scale, and (2) operators of large farms are more schooled than operators of small farms. In regression analysis of data for U.S. agriculture in 1959, I found:

1. Whenever the schooling discrepancy between large and small farms is itself large, measured scale economies are also large *if* the region being considered is "active" in agricultural research. In other words, I found significant evidence of positive interaction between research and scale-education bias in explaining measured scale economies.

2. The comparative advantage associated with increased schooling is partly eroded by extension activity: there is negative interaction between extension and education-scale bias. Extension refers to days spent on farms by Federal Extension Service personnel. These results are certainly consistent with education being something like extension, which facilitates the use of information.

As soon as the information paper is finished, it will be combined with the scale-economy paper and a closely related earlier one, "Education in Production"

(J.P.E., Jan. 1970). This monograph will summarize some of the theoretical and empirical linkages between information, education, and productivity.

In a closely related project that uses new data and the more conventional production-function context, Bob Evenson and I are exploring the impact of education—research—extension on agricultural productivity. Although this project has been alive for about one year, all of the initial effort has been concerned with data preparation. The end of preprocessing is in sight, so that serious analysis will soon begin.

Finis Welch

Aptitude, Education, and Earnings Differentials

A paper on "Ability and Schooling as Determinants of Lifetime Earnings or If You're So Smart, Why Aren't You Rich?" (published in the May 1971 *American Economic Review*, Papers and Proceedings) summarizes some results obtained on the relationships between earnings, schooling, ability, and demographic factors at different points of the life cycle of earnings, and between discounted lifetime earnings and these same factors. This study is based primarily on a sample obtained by D. C. Rogers,² supplemented by calculations from Professor Torsten Husén's Malmö data and Project Talent data described in last year's *Annual Report*.

The Rogers sample included 345 males who were for the most part tested for IQ in the eighth grade in 1935 and who answered questionnaires on earnings and other personal characteristics in 1966. It is argued that representing earnings as a linear function of IQ measures and schooling attainment is probably an erroneous specification, both because of the well-known positive association between IQ and schooling attainment and the strong positive association of schooling and earnings. An approximate chi-square test rejected (at the 5 per cent level) the assumption of identical coefficients on IQ when separate linear regressions are estimated for different schooling attainment groups. Subsequent regressions use the logarithm of earnings as the dependent variable, and regress earnings on IQ and other control demographic variables within schooling groups.

Despite problems from the small samples, the main results suggest that measured IQ has a negligible effect on earnings for those not graduating from high school, and has a modest but increasing effect as schooling attainment is increased. For those with two or more college degrees, an additional IQ point is associated with a 0.78 per cent increase in lifetime earnings discounted at 4 per cent, and with a 1.32 per cent increase in earnings in a single year (1965). There is a tendency for the ability coefficient to increase with job experience, within constant schooling attainment regressions. If ability is not included as a variable, the bias in the apparent returns to college education for an average-ability high school graduate is about 13 per cent for 1965 earnings. The corresponding bias for the average-ability high school graduate obtaining two or more degrees is 18 per cent.

Subsequent calculations, based on these and on the NBER-Thorndike sample, reported at the COBRE conference at the University of Chicago give strong statistical support to the hypothesis that IQ-measured ability is a complement of both schooling and job experience on full-time earnings.

John C. Hause

LAW AND ECONOMICS

Introduction

The National Science Foundation recently made a grant to the NBER to enable us to continue our work on the economic analysis of crime and certain legal institutions. Some studies already under way are reported on below by Isaac Ehrlich, William Landes, and Richard Posner. These deal with the change over time in the

²D. C. Rogers, "Private Rates of Return from Education in the United States: A Case Study," *Yale Economic Essays*, Spring 1969, p. 9.

incidence of felonies, the analysis of the courts, including the bail system, and the effect of liability laws on the incidence of accidents.

We are formulating plans for some additional studies. Under consideration is a study of victimization, based on a survey conducted several years ago for the Presidential Crime Commission. This survey provides information on the rate of victimization for about ten felonies classified by income, age, race, sex, education and several other variables. Such a study would examine the relationship between victimization and these characteristics.

We are also considering a study of the jury system. How much this system costs society, who actually serves and how that is related to the method of choosing and compensating jurors, and how it affects and is affected by court delay.

Gary S. Becker

The Time Trend of Crime in the United States

Following my theoretical work on participation in illegitimate activities and the empirical investigation of crime variations across states in the United States in 1960, 1950, and 1940 (described in the *49th* and *50th Annual Reports*) I have been attempting to apply the general model to the analysis of crime variations over time in the United States as a whole. The aim of the present study is to investigate the interaction between the time trend of specific index crimes, law enforcement activities, and legitimate and illegitimate economic opportunities in the United States from the early 1930's to date. (The United States has maintained systematic national statistics on the volume of specific crimes only since 1933.) In addition, it is hoped that the study will shed light on the factors underlying the apparent growth in specific crimes against property (robbery, burglary, larceny, and auto theft) and in aggravated assault; the reported rates for these crimes have almost invariably doubled within the last decade.

In view of the consistency of our simultaneous equation model of law enforcement and crime with the empirical evidence on crime variations across states in the United States, we have aimed at using an equivalent framework in the analysis of crime variations over time. Due to statistical exigencies, however, we have so far dealt only with a subset of index crimes and an incomplete set of explanatory variables. The crimes investigated have been murder and nonnegligent manslaughter, aggravated assault, robbery, burglary, and auto theft. (Larceny and forcible rape have been excluded because the definitions of these crimes changed during the period.) The dependent variables are annual rates of these crimes, based on newly adjusted unpublished figures provided by the Uniform Crime Reporting section of the F.B.I. (UCR). Explanatory variables include UCR yearly estimates of the probabilities of apprehension for specific crimes, measured as the percentage of offenses cleared by arrest, Bureau of the Census annual estimates of unemployment rates in the civilian labor force, the proportion of nonwhites and the 15-25 age group in the total population, the sample year (a "pure" measure of trend) and a dummy variable distinguishing the years 1943-45 from other years.

Plans call for the use of other explanatory variables. It would be desirable to combine data on arrests with data on convictions in order to construct measures of the joint probability of apprehension and punishment for specific crimes. We have not yet found systematic time-series data on the mean or median time served by offenders in U.S. prisons and on income inequality (the percentage of families below one-half of the median income)—two variables found to be significantly related to the rate of specific crimes in our cross-state regressions—and current efforts are partly aimed at estimating efficient approximations for these variables. Also, the absence of complete series on public and private expenditure on law enforcement and protection against crime has so far prevented the application of simultaneous equation regression techniques and only simple multiple regression techniques have been used.

In spite of the shortcomings of the regression framework employed, the results

of the preliminary time-series regression analysis has been consistent with our hypotheses and with the results of our cross-state regression analysis. Specific crimes were negatively and significantly related to the level of current or one-year lagged estimates of the appropriate probabilities of apprehension. Moreover, despite the differences between the set of explanatory variables used in the cross-section and time-series regressions, there is a remarkable agreement between some critical coefficient estimates. For example, the point estimate of the effect of the probability of apprehension and imprisonment on the rate of specific crimes from the cross-state regressions are very close to the estimated effect of the lagged probabilities of apprehension on the rate of the same crimes derived from the time-series regressions.

The incidence of all specific crimes against property included in our analysis (robbery, burglary, and auto-theft) were found to be positively and significantly related to the rate of unemployment over time. Crimes against property are thus found to vary negatively with the business cycle. However, no such significant correlation has been observed in the case of crimes against the person (murder and aggravated assault). All specific offenses were found to vary positively with the percentage of nonwhites and young age groups in the population, and most crime rates showed a decline during the years of U.S. involvement in World War II. The "trend" variable was found to be positively related to the rate of burglary and aggravated assault only. It is possible that this "trend effect" simply reflects the increase in the proportion of burglaries and aggravated assaults *known* to the police over time; reporting bias may have been relatively smaller in the case of murder, auto theft, and robbery.

The results of the preliminary regression analysis offer an explanation for the recent surge in reported crimes against property and assaults in the United States. To a large extent, this surge may have been the result of the sharp decline in the probability of apprehension for these crimes within the last ten years: for example, the probability of apprehension for burglary declines by 31 per cent between 1959 and 1968, and that for robbery by 35 per cent. Of course, our preliminary regression analysis has not yet confirmed the direction of causality underlying the negative partial correlation between crime rates and probabilities of apprehension over time, and this requires the application of simultaneous equation techniques as well as an analysis of changes in reporting bias. Current efforts are thus aimed at extending the set of explanatory variables and, in particular, at applying the simultaneous equation model of law enforcement and crime in the analysis of the time trend of specific crimes in the United States.

Isaac Ehrlich

An Economic Analysis of the Courts

A manuscript entitled "An Economic Analysis of the Courts" has been completed and was published in the *Journal of Law and Economics*, Spring 1971. A model, described in the 1969 and 1970 *Annual Reports*, has been developed to identify the variables relevant to the choice between a trial and a settlement. The model's basic assumption is that both prosecutor and defendant maximize their utility, appropriately defined, subject to a constraint on resources. We show that the trial versus settlement decision depends on estimates of the probability of conviction by trial, the severity of the crime, the availability and productivity of the prosecutor's and defendant's resources, trial versus settlement costs and attitudes toward risk.

Multiple regression techniques are used to test a number of hypotheses derived from the model. Considerable evidence was found to support the hypothesis that an increase in the cost differential between a trial and settlement reduces the demand for the former and increases the demand for the latter. Other findings are that cases involving larger sentences go to trial more frequently, and that convictions leading to prison sentences tend to be lower in districts characterized by

relatively high average wealth, while convictions resulting in monetary fines are greater in the same districts. These results are consistent with the model's prediction that a wealthier defendant has stronger incentives to invest financial resources in his case if the penalty is a jail sentence, and less incentive if the penalty is a fine. Conviction rates are higher in county courts where judicial expenditures are larger, a finding consistent with the hypothesis that the size of the prosecutor's budget determines the proportion of defendants convicted.

Further empirical research in this area will include an analysis of the relation of detailed characteristics of defendants (e.g., age, sex, race, and schooling) to the disposition of cases, an analysis of variations in sentencing for similar offenses, and a comparison of court systems in England and Canada with the United States.

William M. Landes

The Bail System

In this study I develop a model for an optimal bail system. My approach is to derive a social benefit function that incorporates both the gains to defendants from being released on bail and the costs and gains to the rest of the community from their release. I then determine the level of resource expenditures on the bail system and the optimum number of defendants to be released on bail. The specific inputs into the social benefit function include (a) the monetary and nonmonetary gains to defendants, (b) the savings in detention costs to the community (e.g., savings in expenditures on jails, guards, food, etc.), (c) the harm or damage from additional crimes in the period of pretrial release which would not have occurred had these defendants not been released, and (d) the costs of reapprehending defendants and reducing the time of pretrial detention.

An important feature of the analysis is that it permits consideration of alternative methods to select defendants for release or, in effect, alternative bail systems. Two systems are analyzed. One, which corresponds to most existing bail systems in the United States and other countries, requires that defendants pay for their release. In the other, defendants are compensated for their detention. Although the optimality conditions are largely unaffected by whether the defendant has to pay or is paid, there are several advantages to a system in which defendants are paid. The major advantage is elimination of the punitive aspect of the bail system, since those detained are fully compensated for their losses. Other advantages are that compensating defendants tends to reduce discrimination against low-income defendants, and provides incentives for the state to improve pretrial detention facilities.

For the empirical analysis, I plan to compare the workings of the actual bail system with an optimum one. Casual evidence suggests that certain implications of the optimal system—for example, the setting of higher bail charges for defendants accused of more serious crimes and for persons with previous convictions—are found in the actual system. Next, I plan to identify the factors that give rise to variations in the amount of bail charged and the likelihood of release.

William M. Landes

Accidents and Liability Law

We are planning to conduct studies of the economics of accidents and of the legal and regulatory controls of accident-causing behavior. A first draft has been completed on a study of the negligence system of accident control as it operated in the period 1875-1905. The study, based on a sample of legal decisions and on statistics of accidents during the period, attempts to explain and appraise the economic policies that underlie the negligence system. The tentative conclusion is that the system was reasonably designed to bring about an efficient, although not necessarily socially just or acceptable, level of accidents and safety.

William Landes and I are in the first stages of a projected study of the effect of

the U.S. workmen's compensation laws, first enacted during the 1900's, on the industrial-accident rate. The purpose of the study is to test the widely asserted proposition, which seems contrary to the predictions of economic theory, that the laws brought about a reduction in the accident rate. Other projected studies involve research into the effect of new legal standards on the rate of accidents caused by defective products and into secular changes in the economic theories underlying methods of legal and regulatory control of accidents.

Richard A. Posner

POPULATION STUDIES

The Economics of Completed Fertility and Fertility Control

The major portion of my work this year has involved attempts to test empirically the implications of a model of household fertility behavior developed in my doctoral dissertation (University of Washington, 1971). This model is described in Part I of this Report in my paper with Warren Sanderson. One of the factors stressed in that paper is the importance of proper specification of regression models in testing a theory. Recently, we have implemented a set of regression specification error tests contained in a program developed by James Ramsey of Michigan State University. These tests for specification errors, such as heteroscedasticity, non-normality, omitted variables, etc., provide a powerful set of tools for choosing between alternative forms of regression equations whose implications for economic models may be very different.

The secular decline of fertility and the development of a negative relationship between socioeconomic status and fertility have both been explained by the increase in the use of birth control over time and by the alleged pattern of diffusion of contraception from upper class and urban groups to lower class and rural groups. As recently as 1965, Bumpass and Westoff³ found that almost 20 per cent of American births were unwanted by the parents and that the incidence of unwanted births was much higher among nonwhites and those with low education levels. Such explanations and findings have formed the basis for a number of past, present, and prospective family planning programs in both advanced and underdeveloped countries.

I have developed an economic model of fertility control which, superficially at least, seems to be consistent with the observed pattern of diffusion of fertility control techniques over time and cross sectionally. It also appears to be consistent with the distribution of "unwanted births" found by Bumpass and Westoff, even though all individuals in the population are assumed to have identical knowledge and attitudes toward birth control techniques and practices. The basic factor in this model that accounts for differential choices of fertility control techniques and success in avoiding unwanted births among various groups is the proposition that there are economies of scale in birth control. This is true in the sense that the marginal (psychic) cost per birth avoided tends to be a decreasing function of the number of births avoided. Modern techniques, such as the pill, have low marginal costs relative to primitive methods, such as withdrawal, and will be used by those who wish to avoid a large number of births. The "optimal" number of unwanted births will be an increasing function of the marginal cost per birth avoided. Hence, groups whose desired fertility tends to be high will also tend to have larger numbers of unwanted births. The pattern of desired fertility and, therefore, the pattern of unwanted fertility can be predicted with the fertility demand function discussed above. I expect in the near future to use the 1965 National Fertility Survey data used by Bumpass and Westoff to test such implications of the fertility control model.

Robert J. Willis

³ Larry Bumpass and Charles Westoff, "The 'Perfect' Contraceptive Population," *Science*, September 1970, pp. 1177-1182.

One goal of the population project at the National Bureau is to gain insight into the interactions of economic and demographic phenomena. We have been focusing our attention on one aspect of this problem—the effect of economic conditions on natality. Our study follows the suggestion made by Easterlin that recent variations in the fertility of American women may be understood within a unified historical framework. The research has progressed along two related paths. The first is an attempt to obtain better measures of the course of fertility changes in the United States since 1880, and the second is the creation of a life-cycle model of family behavior in which the number and spacing of children are endogenous. The model and the fertility measures have been created in a consistent manner; integrating them is the next stage of the research.

Roughly speaking, empirical measures of fertility depend on observations on births (or very young children) and observations on the size of the female population that risk having these births. Until recently, annual data on total births by color in the United States dated back to 1909, and data on white births by nativity of mother back to 1917. In 1963, Coale and Zelnik⁴ published new annual estimates of white births from 1855 to 1934 and corresponding estimates of the native white population by single years of age at census dates. This procedure resulted in estimates of census underenumeration rates of native white at each age, which Coale and Zelnik assumed are equally applicable to foreign-born whites, enabling them to compute crude birth rates and total fertility rates for the entire white population. Preliminary work has shown that the Coale and Zelnik annual birth estimates and, therefore, population and underenumeration estimates, may be too low by an amount which increases as one goes back in time. We have used the 1960 Census one-in-one-thousand sample to divide the new white birth estimates into children born to native-white mothers and those born to foreign-born white mothers. This allows us to obtain annual estimates of children born to native white women in relation to the number of native white women fifteen to forty-four years old. We can thus chart the historical path of fertility decline in this country with a measure which is less affected by cycles in immigration.

From 1920 onward, we estimate the age distribution of native white women by single year of age and parity-specific birth probabilities. These birth probabilities enable us to trace life-cycle fertility patterns for cohorts of women. Work is in progress on revising the preliminary set of these probabilities that has been computed. One of the problems that still must be confronted in this task is to reconcile apparently inconsistent census and vital statistics data. This problem has remained unresolved since it was first noticed over two decades ago.

A numerically specified model of household life-cycle behavior has been created (see my paper with Willis in Part I of this Report) to gain some understanding of the life-cycle fertility patterns of cohorts. Essentially, it is a theory of the allocation of the wife's time between child-rearing activities, other household pursuits, and labor force participation. Child-rearing is assumed to be more time-intensive than other household activities, and younger children are assumed to be more time-intensive than older children. The model currently assumes the hourly market wage paths faced by each parent, the time path of nonlabor income, the structure of household production functions, the utility function, and fertility control costs to be exogenous. It determines the number of births the couple desires, the year in which each child is born (and hence child-spacing), and, for each year of married life, the amount of time each parent spends on each child, on non-child-related activities, and in labor market participation, and the amount of money the couple spends on each child and on non-child-related activities.

The model is solved by using an iterative dynamic programming technique

⁴ Ansley J. Coale and Melvin Zelnik, *New Estimates of Fertility and Population in the United States*, Princeton, 1963.

called successive approximations. In essence, the particular algorithm that was used decomposes n -dimensional dynamic programming problems into iterations each of which is composed of about $3n$ 1-dimensional dynamic programming problems. Experimentation with this algorithm has been sufficiently encouraging to suggest that it may have wider applicability.

Warren Sanderson

Economics and Fertility

I am attempting to test the applicability of economic theory, especially the theory of the allocation of time, to explaining the differences in completed fertility and in child-spacing and timing observed in cross-sectional data.

Regression analyses of subsamples of white women aged forty to forty-nine, who were in the 1960 Census one-in-one-thousand sample, tended to support the theory of fertility behavior developed by Willis (see the Willis-Sanderson paper in Part I of this Report). Among women in the labor force, those who had higher wage rates had fewer children, *ceteris paribus*, than those with lower wage rates; but the coefficient of the husband's labor income and the family's nonlabor income was positive. For women not in the labor force, the potential market wage was estimated from their educational attainment and other factors. The coefficient of the potential market wage was negative. In this equation, the coefficient of the husband's labor income and the family's nonlabor income was again positive, but smaller than for women in the labor force and no longer significantly different from zero.

Preliminary analysis of published Census reports on child-spacing indicates that, holding family size and mother's age constant, the average first birth interval, i.e., the length of time from marriage to first birth, is longer for each successively higher level of education. Higher order birth intervals (as well as the duration of marriage at the time of higher order births) are shorter at higher levels of education, except for high school dropouts who have the longest intervals. Age at marriage follows a complementary pattern, increasing from the class "education = 0.7 years" through the class "education = 16 or more years," except for high school dropouts who were younger at marriage than any other education group.

Progress is being made in estimating, from the one-in-one thousand sample tape, mean birth intervals and other sample statistics for cross classifications of various subsets of women. It should be possible to examine not only different groups of women than are described in the published reports, but also classifications by more and different variables—e.g., age at marriage, family income, parents' education, and difference in parents' ages—and more detailed classifications within variables. I am also trying to obtain information relevant to birth interval studies for women in the 1967 Survey of Economic Opportunity.

Sue Goetz Ross

4. BUSINESS CYCLES

INTRODUCTION

Much of the business cycle research during the past year centered around a colloquium on "The Business Cycle Today," the first of a series held in conjunction with the National Bureau's Fiftieth Anniversary. Papers by members of the Bureau's research staff discussed at the colloquium, details of which are reported elsewhere in the *Annual Report*, include Ilse Mintz on growth cycles, Solomon Fabricant on current business developments, Victor Zarnowitz on short-term forecasting methods, and Yoel Haitovsky and Neil Wallace on stochastic simulations of econometric models.

Other papers growing out of the discussions at the colloquium include an occasional paper by Mintz on U.S. growth cycles (about to be sent to the Directors for review); a paper by Fabricant, which concludes that the slowdown in the U.S. economy during 1969-70 was a "classical" recession, not simply the declining phase of a rate-of-growth cycle; and a paper by Zarnowitz, presented at the December meetings of the American Economic Association, which details a research agenda for the 1970's in the area of business cycles (see Part I of this Report).

Work has continued during the past year on a number of studies. These include the research of Zarnowitz and Boschan on simulation tests of econometric models, the work of Friedman and Schwartz on monetary relationships in U.S. and British business cycles, the studies of Gregory Chow and An-loh Lin on the testing of cyclical models and the interpolation of time series by related series, and Benoit Mandelbrot's work on the cyclical properties of time-series data. These studies have all been reported on in past *Annual Reports*.

Some thought has been given during the past year to the direction most appropriate for future business cycle research at the National Bureau. Discussion at the business cycle colloquium, in particular the papers by Mintz, Fabricant, and Geoffrey Moore, suggests reformulating the concept of business cycles to embrace alternating periods of relatively high and relatively low—not necessarily negative—growth. The National Bureau's measurements of leads, coincidence, or lags at classical business cycle peaks and troughs may need to be supplemented by measurements relative to growth-rate peaks and troughs. It is possible that some "leading indicators" tend to behave differently when a retardation in growth is in prospect than when a full-fledged recession is in prospect. In addition, one might want to distinguish more sharply than in the past between cyclical movements in the "real" economy and those in the price level or in current-price aggregates.

We are considering also the possibility of studying potential output. The policy implications of a slowdown in economic activity which just gets the economy back to potential (as in 1966-67) are quite different from those of a slowdown or recession which puts the economy well below potential (as in 1969-70). But potential output is an elusive concept, and questions about labor supply, productivity growth, and capacity growth need to be thoroughly examined with an eye toward developing a conceptually more satisfying measure.

F. Thomas Juster

RECENT ECONOMIC CHANGES AND THE AGENDA FOR BUSINESS CYCLE RESEARCH

During the past year two papers were written dealing with economic changes during 1969-1970 and what they suggest for the study of business cycles. One was offered for discussion in the 50th Anniversary Colloquium on "The Business Cycle Today," held in September 1970. The other, which extends the review through to the end of 1970, was published as a supplement to National Bureau Report 8. The main points are as follows:

1. Any doubts economists may have had in the spring of 1970, or even later, about the character of the economic slowdown already evident during the winter

of 1969-70, have been largely resolved by subsequent events. We now express the judgment that the business cycle expansion which, according to the National Bureau's chronology, began in February 1961, came to an end during the second half of 1969. Declines during and since 1969, though modest in most types of economic activity, have been widespread and persistent. Further, the declines appeared, as a rule, first among the "leading" indicators, then among the "coinciding" indicators, and finally among the "lagging" indicators. In these several respects, the economic changes of 1969-70 bear a family resemblance to the economic changes that have characterized recessions of the past. The resemblance is sufficiently close to warrant designating the 1969-70 period as one of recession.

2. We have decided, at this writing, to put the tentative peak date at November 1969. December, a month later (or even October, a month earlier), seems almost as tenable a choice. In any case, the difference is slight, data revisions will undoubtedly be made later, and our choice is clearly marked "tentative." The expansion from February 1961 to November 1969 lasted, then, 105 months. This is the longest expansion listed in the National Bureau's chronology (which begins with 1834). The previous longest expansion, which took place between 1938 and 1945, lasted eighty months. The average of all expansions after 1834 is about thirty months. Further, it is clear at this writing (when the relevant statistics that are available run mostly through the first quarter of 1971) that the recession that began in November 1969 continued to November 1970. If subsequent developments should indicate that a business cycle trough was in fact reached in November 1970, as seems likely—we are too close to that month to be sure—the recession will have lasted twelve months. In that case, the recession was much shorter than the average of all recessions, nineteen months, and a little longer than the average of other post-World War II recessions, ten months.

3. As already mentioned, the decline in aggregate economic activity during the recession of 1969-70 has been mild. Measured by either total decline or rate of decline in such important "coinciding" indicators as production, physical volume of sales, employment, and unemployment (inverted), the recession has been among the mildest in our record. Specifically, it has on the whole been as mild as, if not milder than, the very mild recession of 1960-61. It is definitely milder than the recession of 1957-58. It may also have been as mild or milder than the very mild recession of 1926-27, to judge from the imperfect records available prior to World War II.

4. However, the indicators cited do not tell the whole story about the recession. In financial markets, particularly, the recession of 1969-70 cannot be classified as exceptionally mild. The prices of corporate stocks declined somewhat more than in other postwar recessions, though not nearly as much as in the two recessions of the 1930's. The rapid fall in the prices of long-term debt securities, evident during the expansion, continued during the first half of the recession as interest rates on new issues rocketed to exceptionally high levels, and then sharply reversed itself. And the liabilities of business failures more than doubled from levels already higher in November 1969 than at the beginning of earlier post-World War II recessions.

5. The recession was exceptional also in that most categories of prices—and thus also the general price level—continued to rise throughout. The pace of change did not accelerate, as it had been doing before the recession began, but it remained at a high level, averaging 5.3 per cent per annum in the case of the GNP implicit price deflator. With real GNP falling only slightly, the continued rise in the general price level meant that GNP in current dollars also continued to rise throughout 1969 and 1970. This was true, as well, of some of the other important coinciding indicators expressed in current dollars.

6. There is no doubt that the automobile strike of September-November 1970 reduced the level of aggregate economic activity in those months. But we did not try to exclude the effects of the automobile strike when we determined the cyclical

character of economic changes during 1969-70. To do so would mean applying a procedure we have not applied in the past. In effect, we say that the 1969-70 recession may have been extended, or deepened, by the strike, rather than that the recession ended before the strike began. Much the same reasoning applies, naturally, to the effects on business conditions of the reductions in defense contract awards and expenditures during 1970; and the effects on unemployment of the release of men from the armed forces.

7. The mildness of the 1969-70 recession and the other recessions in the United States in the postwar period, as well as in other industrialized economies, raises many questions about the National Bureau's business cycle research program. One is how the Mitchell-Burns analytical description of business cycles can be adapted to apply to an economy in which recessions in aggregate economic activity are marked by a rate of growth that is inferior to the trend rate but not necessarily negative; or, alternatively, an economy in which recessions consist of a widening of the gap between potential GNP and actual GNP, while actual and potential GNP continue to grow. Another question bears on the conceptual and statistical problems of defining and measuring potential GNP, if growth cycles are to be identified. A third question concerns the National Bureau's chronology of business cycles—not whether to drop it, for its use remains widespread, but rather whether it should be extended to date not only peaks and troughs in "classical" business cycles, but also in growth cycles. This would mean including the 1966-67 and other "slowdowns" that appear in Ilse Mintz's chronology (see her report below). And a fourth question relates to the economic instability associated with seasonal movements in production and employment. These may have grown in relative importance as business cycles have become milder, but in any case seasonals make for a good amount of unemployment. There has been no comprehensive survey of this type of fluctuation since Kuznets' treatise of almost forty years ago.

Solomon Fabricant

BUSINESS CYCLE TURNING POINTS

The report on my study of United States growth cycles, given in September 1970 at the NBER Colloquium on "The Business Cycle Today," will be published in a conference volume. I hope to submit shortly a revised and expanded version of the study to the Board of Directors, with a view to publication as an Occasional Paper.

The revision consists partly in the substitution of an improved list of indicators for the one used in the previous paper. An index based on the revised list and analyzed by computer reproduces all eight turns from 1948 to 1961 in the same months which had been set by traditional subjective methods. Also, I plan to examine the behavior of a composite indicator consisting of the deflated counterparts of the new list.

The growth cycle chronology will be re-examined on the basis of the new indicator list. The expanded study will also offer measures of amplitude, smoothness, and timing not previously included.

Ilse Mintz

MONEY

During the past year we completed the revision of about half the chapters of the draft of "Monetary Trends in the United States and the United Kingdom: Their Relation to Income, Prices, and Interest Rates" that were outlined in the *50th Annual Report*. We expect to finish the draft during the coming year.

Milton Friedman
Anna J. Schwartz

STUDY OF SHORT-TERM ECONOMIC FORECASTING

I have prepared a report, "Forecasting Economic Conditions: The Record and the Prospect," for the NBER Colloquium on "The Business Cycle Today," held on Sep-

tember 24, 1970, in New York. The first of its main parts identifies and reviews the major directions of National Bureau research in economic forecasting and related topics; the second brings up to date and evaluates some results of this work; and the third discusses our plans for future studies.

Further work has been done by Charlotte Boschan and myself, with the able assistance of Josephine Su, on the business cycle analysis of econometric model simulations. In addition to the earlier study of the Wharton, OBE, and FRB-MIT-PENN models, this analysis now also covers the nonstochastic sample period and stochastic ex ante simulations of the Brookings model. I presented a brief summary interpretation of the main results of this study at the Second World Congress of the Econometric Society in Cambridge, England, in September 1970. This paper, "Econometric Model Simulations and the Cyclical Characteristics of the U.S. Economy," has since been revised for publication.

My paper on "New Plans and Results in Economic Forecasting" is included in Part I of this Report. It was presented at the Annual Meeting of the American Economic Association and the American Statistical Association in their joint session on "New Directions in National Bureau Research—II" in Detroit on December 30, 1970.

In the early months of 1971 much of my time was devoted to writing an introductory essay for, and editing, "The Business Cycle Today," the volume of proceedings of the NBER business cycle colloquium. In this essay, an attempt is made to provide a background for the colloquium reports by surveying broadly several topics, including the apparent moderation of business cycles in recent times; the role of economic theory and research in this development, with particular reference to National Bureau studies and their interaction with other work; the evolution of the conception of business cycles as influenced by historical changes, accumulation of empirical evidence, development of theoretical and econometric models, and other relevant factors.

Victor Zarnowitz

THE DECOMPOSITION AND EVALUATION OF MACROECONOMETRIC FORECAST ERROR

We are in the final stages of preparing a monograph entitled "Forecasts with Quarterly Macroeconometric Models." This year we have added to our previous work by developing a procedure for macroeconomic forecast error decomposition and by completing our evaluation of U.S. quarterly macroeconomic forecasts through the third quarter of 1969.

The need to decompose the forecast error from econometric forecasts arises from the difficulty of pinpointing the sources of the forecast error for any particular endogenous variable that is simultaneously determined with many other variables. Take as an example the following simple linear system:

$$\text{Aggregate consumption equation: } C_t = \alpha + \beta DI_t + U_t \quad (1)$$

$$\text{Aggregate investment equation: } I_t = \gamma Y_t + W_t \quad (2)$$

$$\text{Retained earnings equation: } RE_t = \xi Y_t + V_t \quad (3)$$

$$\text{National income identity: } Y_t = C_t + I_t + G_t \quad (4)$$

$$\text{Disposable income identity: } DI_t = Y_t - RE_t - T_t \quad (5)$$

$$\text{Government expenditure: } G_t = \text{exogenous} \quad (6)$$

$$\text{Tax revenues: } T_t = \text{exogenous} \quad (7)$$

Here the forecast error for consumption is expressed in the following equation:

$$\delta C = \frac{1}{1 - \beta(1 - \xi) - \gamma} [(1 - \gamma)\delta U - \beta(1 - \gamma)(\delta T + \delta V) + \beta(1 - \xi)(\delta G + \delta W)] \quad (8)$$

where δC is the total forecast error, δT and δG are the differences between the guessed at (ex ante) and the realized (ex post) values of the exogenous variables, and δV , δW and δU are the errors that remained in the individual structural equa-

tions after the constant terms in the equations were adjusted by the econometric forecaster. The total error for C may be decomposed into additive components reflecting the direct effect of the error originating in the equation itself (δU), the indirect effect of this error $(1/1 - \beta(1 - \xi) - \gamma) \beta(1 - \xi)\delta U$, the effect of the errors in the guessed at values of the exogenous variables $(1/1 - \beta(1 - \xi) - \gamma) \beta[(1 - \xi)\delta G - (1 - \gamma)\delta T]$, and the effect of the errors in the other equations of the system $(1/1 - \beta(1 - \xi) - \gamma) \beta[(1 - \xi)\delta W - (1 - \gamma)\delta V]$.

We have extended this approach to the decomposition of error for nonlinear systems and for multiperiod forecasts. Application of this decomposition method to Wharton forecasts from 1966.3 through 1969.3 revealed that the wage bill equations had caused consistent underpredictions of GNP when no constant adjustments were used. It also showed that, although individual equations in the consumption sector were improved by the forecaster's adjustments of the constant terms, the total error in the consumption sector was not reduced in proportion to the single-equation improvement because offsetting errors were reduced in the adjustment process.

As part of updating our work on evaluating ex post forecasts, we have computed the average absolute forecasting error (AAFE) for the Wharton (Wharton School of Finance and Commerce) and OBE (Office of Business Economics of the U.S. Department of Commerce) models by using the equation adjustments that they used in ex ante forecasts (original adjustments—OR) and substituting realized for guessed values of the exogenous variables (ex post forecast). For comparison we have computed the AAFE for quarterly "no change" and "same change" forecasts, as well as for autoregressive-technique and reduced-form equations. The coefficients for these benchmark models were estimated over sample periods identical to those of the econometric models. The autoregressive equation expresses the dependent variable as a function of its own last four values. We used the reduced-form model proposed by L. C. Anderson and J. Jordan in the *Federal Reserve Bank of St. Louis Review* in November 1968. This is a single-equation model where the change in nominal GNP is a function of the change in the money supply and high employment, net of government expenditures, over the current and the last three quarters.

The results of the calculations included the following:

Average Absolute Forecasting Error One Year Ahead

	GNP (billion dollars)	GNP (billion 1958 dollars)	Unemployment (percentage points)
Sample Period 1953.2-1966.4; Forecast Period 1967.2-1969.3			
OBE-OR & ex post	11.18	5.75	0.39
Autoregressive	3.53	9.32	0.07
Same change	9.47	7.87	0.27
No change	45.24	18.79	0.19
St. Louis	8.25	n.a.	n.a.
Sample Periods 1948.1-1964.4 (and 1953.1-1968.3 for 1969); Forecast Period 1966.3-1969.3			
Wharton-OR & ex post	8.86	7.98	.62
Autoregressive	14.23	4.77	.60
Same change	10.81	8.51	.31
No change	38.30	15.60	.15
St. Louis	6.57	n.a.	n.a.

Yoel Haitovsky
George Treyz
Vincent Su

INTERPOLATION OF TIME SERIES

Two papers are being prepared for publication. The first presents a best linear

unbiased estimator, using related series, for distributing an observed time series based on a given calendar span among the shorter time units of which it is composed. Our estimator has been derived from the specification that a linear stochastic relation based on the shorter time units exists between the time series to be distributed and the related series used for distribution. Several special methods can be deduced, according to the particular structure assumed for the disturbance term in the relation. According to these methods, the estimate will consist of systematic and residual components.

An important use of such an estimating relationship is in the construction of monthly series for GNP and its components. Alternative methods were tested by constructing estimates of quarterly series for the GNP components from annual series, and comparing estimates with actuals. Following are some general observations from empirical results:

1. The estimation by related series performs much better, as judged by mean square error, than does a simple linear interpolation without related series, for the following cases: gross national product, personal consumption expenditures for autos and parts, personal consumption expenditures for nondurable goods, gross private domestic expenditures on nonresidential structures, gross private domestic expenditures on nonfarm residential structures, government purchases of structures, change in nonfarm business inventories, exports, and imports. However, the opposite is true for personal consumption expenditures for durable goods other than autos and parts, personal consumption expenditures for services, gross private domestic expenditures on producers' durable equipment, government purchases of goods, and government purchases of services.

2. The inclusion of the estimated residual as a part of the estimating equation substantially improves the efficiency of the estimate in all cases.

3. When serial correlation in the monthly disturbance term is taken into account in the interpolation, the efficiency of the estimate is improved for all cases mentioned in 1 above, except gross national product and change in nonfarm business inventories.

4. When a series is aggregated from several individual series (e.g., personal consumption expenditures as the sum of expenditures for durables, nondurables, and services), the question arises as to whether interpolation should precede or follow aggregation. The answer turns out to depend partly on the nature of the serial and contemporary cross correlations among individual disturbances. The analytical and the empirical results indicate that the existence of negative cross correlations tends to be more favorable to the interpolation of an aggregated series than otherwise.

The second paper deals with the extrapolation of a time series beyond a sample period by means of related series, and is an extension of the first one. Specifically, we are interested in estimating GNP components for months beyond a sample period over which both quarterly data on the components and monthly data on their related series are available. So far the analysis has been concentrated on GNP in current and constant dollars and the GNP deflator.

Monthly GNP components, of course, would help significantly in providing quick and more accurate appraisals of the current state of the economy. In fact, Canada has recently started issuing a monthly index, available between forty and fifty calendar days after the month ends, for real domestic product. Available information for estimating GNP becomes much more limited and imprecise and the estimation has to rely increasingly on interpolation and extrapolation as the time unit of measurement is shortened from a quarter to a month. In spite of this data problem, it can be conjectured that monthly estimates for the U.S. GNP components will be officially published in the near future. We have found that the related series selected for the current-dollar GNP and the deflator are quite satisfactory. At the present time, these monthly series are officially released within forty-five calendar days after the end of the month. This would necessitate a time

lag of one and one-half months before the monthly estimate of GNP can be given by our extrapolation procedure.

The papers reported here are by-products of a study of monthly econometric models for the U.S. economy. Part of the work is being done jointly with Gregory Chow of Princeton University.

An-loh Lin

DETERMINANTS OF INVESTMENT

A paper on "Components of Capital Expenditures: Replacement and Modernization Versus Expansion" was presented to the Second World Congress of the Econometric Society at Cambridge, England, in September 1970. This paper was based on individual firm data obtained from the McGraw-Hill capital expenditure surveys for 1952-66. The key questions in the surveys were of the form, Of the total amount you now plan to invest in new plants and equipment in [the current year] how much is for: expansion? replacement and modernization? The following findings emerged from intensive statistical analysis.

1. Expenditures planned for replacement and modernization varied over time but were a much more constant proportion of capital stock than were expenditures planned for expansion.

2. While varying less, replacement and modernization expenditures were not a stabilizing substitute for expansion expenditures, but rather moved up and down with expansion expenditures.

3. Expenditures for expansion are clearly related to past and expected sales changes (and to some extent utilization of capacity), particularly in cross-section and industry regressions in which random or transitory components of individual firm variance over time may cancel out.

4. Replacement and modernization expenditures, conversely, are positively related to depreciation charges, to the rate of profit to some extent, and to the age of capital.

A paper analyzing anticipations of capital expenditures several years in the future will be presented at the CIRET meetings in Brussels in September of 1971. Some further analysis of survey and accounting information is also being initiated with regard to the role of depreciation allowances and tax incentives directed toward stimulating investment. Major computer analyses, generally involving time-series and cross-section regressions with appropriate analysis of covariance, are nearing completion, and work on a comprehensive monograph will be proceeding shortly.

Robert Eisner

5. FINANCIAL INSTITUTIONS AND PROCESSES

INTRODUCTION

The high rate of inflation in recent years has made the public more conscious of the real rate of return on investment, as compared with the nominal rate, than it was a few years ago. Efforts to protect investment returns against inflation and to slow the rate of inflation have altered the channels of saving and the financial practices of industrial firms and financial institutions and have, at times, brought severe reactions in financial markets. The National Bureau has undertaken a study of the effects of inflation on financial markets, with the aid of a grant from the Life Insurance Association of America. The individual studies decided on so far cover innovations and shifts in the investment practices of financial institutions, the effects of inflation on market prices of financial assets, and convertible bond financing and purchasing as a response to inflation. Additional studies under consideration are the effects of inflation and inflationary expectations on household investment portfolios and a study of the response of British financial institutions to inflation. The studies on prices, employment, and productivity, reported on by Cagan, Fabricant, and Gordon in section 1, deal mainly with general price and wage level determination, and are complementary to these studies on the financial effects of inflation.

The study of investment policies of the major types of U.S. financial institutions will be under the direction of John Lintner. It will involve interviewing portfolio managers to obtain information not available from published sources, and will attempt to show how far financial institutions have developed new ways to protect their investment portfolios against inflation and the extent to which they have conformed to established theories of behavior.

Thomas Sargent is undertaking the study of asset prices. He outlines below his plans for analyzing the effect of inflation on interest rates. The empirical work will cover a half-dozen or so countries for which data can be obtained for a long period.

The study of bonds convertible into common stock, conducted by Stanley Diller, will develop a series on the "equity yield" of these bonds. Convertible bonds yield an interest return, and also are subject to price changes because of their convertible feature. By comparing their interest return and price with the return and price on similar nonconvertible bonds, one can treat the difference in return as due to the equity component of convertible bonds which reflects expected changes in price. These bonds have become a partial hedge against inflation, and the study will analyze the effect of inflation on their demand, supply, and market rate of return.

Among other areas of the financial research program, the study of interest rates, also supported by grants from the Life Insurance Association, neared completion with the publication of the books *New Series on Home Mortgage Yields Since 1951* by Jack Guttentag and Morris Beck, and *Essays on Interest Rates, Vol. II* (Guttentag, ed.). Phillip Cagan's book on "The Channels of Monetary Effects on Interest Rates" has been revised and edited after staff review. A paper by Anthony J. Curley and Jack Guttentag on "Calculation of Yield and Value of Residential Mortgages" has been reviewed by a staff reading committee and is now being revised.

Several reports from the earlier study of *The Quality of Credit in Booms and Depressions* have recently been published or are in press. These are *The Postwar Quality of State and Local Debt* by George Hempel, *The Cyclical Timing of Consumer Credit, 1920-67* by Philip A. Klein, and *Measures of Credit Risk and Experience* by Edgar R. Fiedler.

The studies of banking markets and of institutional investors are reported on below.

Phillip Cagan
Robert E. Lipsey

INTEREST RATES AND PRICES IN THE LONG RUN

This is a study of the "Gibson paradox," the high correlation between interest rates and prices that characterizes long series of data for a variety of countries. The study begins by re-examining Irving Fisher's explanation of the paradox, which was based on the hypothesis that the nominal interest rate is highly correlated with the anticipated rate of inflation, but that that anticipated rate is a long distributed lag of actual inflation, one so long that anticipated inflation closely resembles the price level. The first part of the study contains an investigation of how plausible it is to assume that investors' anticipations respond with such very long lags. Then we turn to a test designed to determine whether, in explaining the interest-inflation relationship, it is sufficient to use a model that, like Fisher's, incorporates only one direction of influence—from inflation to interest. The test appears to suggest that such an approach is inadequate, and that it is necessary to take into account a second direction of influence, one from interest to subsequent rates of inflation. "Feedback" seems to characterize the interest-inflation relationship. The study concludes with a discussion of how such feedback might emerge. In the process, a model is constructed that provides an explanation of the Gibson paradox that is an alternative to Irving Fisher's.

Thomas J. Sargent

INSTITUTIONAL INVESTORS AND THE STOCK MARKET

The report on *Institutional Investors and Corporate Stock: A Background Report* was completed and submitted to the Securities and Exchange Commission at the end of 1970 and transmitted to the Congress by the Commission, as part of its own study of institutional investors and the stock market, early in 1971. This version was printed by the Government Printing Office and published in March 1971. We are now engaged in some additional editing and in enlarging one appendix, and the Bureau intends to publish this slightly revised version under its own imprint. The contents remain as outlined in last year's *Annual Report*.

Raymond W. Goldsmith

UNION FINANCES

The main purposes of this project, which originated in the Bureau's study of Institutional Investors and the Stock Market, are to develop statistics on the size and composition of the assets, liabilities, receipts, and disbursements of the union movement and its principal subdivisions, and to trace the major changes in the amounts and relative importance of selected financial items. The source data are union reports filed under the Labor-Management Reporting and Disclosure Act of 1958, and other published union reports not subject to that law. All data for the years originally proposed for the project, 1962-68, have been collected and processed; prior to publication, I expect to update the study to include 1969.

The distribution of assets and liabilities for the union movement as a whole in 1968 is reported in Table II-3. Cash has constituted the largest item in the consolidated balance sheet of the union movement, not only in the year shown in the table but throughout the 1962-68 period. Moreover, it has steadily risen in importance since 1962 when cash represented 30.2 per cent of the unions' assets. The single largest type of investment by unions, aside from cash, in 1968 and in all other years, was U.S. Treasury securities, accounting for 18 per cent of assets. Nineteen per cent was in the category of "Other investments" including stocks, bonds (other than those reported as U.S. Treasury securities), certificates of deposits, and other securities. Usually these are reported at cost on union books. Evidently, only a small share of union assets are in stocks yielding dividends, as can be judged from the fact that dividend receipts were less than \$7.5 million in 1968.

TABLE II-3

Consolidated Balance Sheet, American Union Movement, 1968

Item	Amount (million dollars)	Per Cent of Total
Assets		
Cash	\$ 893.7	34.8
Accounts and loans receivable	104.0	4.0
U.S. Treasury securities	464.5	18.1
Mortgage investments	153.5	6.0
Other investments	496.6	19.3
Fixed assets	410.5	16.0
Other assets	46.9	1.8
Total assets	2,569.8	100.0
Liabilities		
Accounts payable	29.2	9.2
Loans payable	28.4	9.0
Mortgages payable	36.2	11.4
Other liabilities	223.0	70.4
Total liabilities	316.9	100.0
Net assets	2,252.9	—

A manuscript reporting and analyzing union finances, as outlined above, is now underway. I expect to complete and submit it for review by mid-year.

Leo Troy

PERFORMANCE OF BANKING MARKETS IN THE PROVISION OF SERVICES TO BUSINESS

The purpose of this study, for which the American Bankers Association provided both financial support and assistance in the acquisition of data, has been to determine whether the prices paid by businesses for bank services are related to the structure of banking markets, as described by such characteristics as the concentration of control over bank deposits and the degree of branching restrictions. Because of regulatory constraints and long-run profit-maximizing criteria, banks attempt to maximize profits on the entire package of services supplied to a customer, rather than on each service separately. Therefore, to estimate the parameters of the relationship between price and market structure, data that describe the entire bank-customer relationship are required, rather than interest rates on loans, which have been used in all previous attempts at empirical estimation of this relationship.

We find that loan rates are positively associated with both concentration and the degree of branching restriction; that is, interest rates on loans are higher as market concentration is greater and/or as branching restrictions tighten. However, estimates imply very small absolute differences in interest rates even for major differences in market concentration and branching restrictions. The regressions on deposit balances imply no association between the size of these balances and either concentration or branching restrictions. Our conclusion is that market structure affects the price paid for the package of services provided business but the magnitude of the impact is extremely small.

A manuscript of the complete report has been revised after review by a staff reading committee. An Occasional Paper entitled "Business Loan Costs and Bank Market Structure: An Empirical Estimate of Their Relations," which represents a major portion of the empirical work, has been approved by the Board of Directors and is in press.

Donald P. Jacobs

The purpose of this study, which has been financed partly by a grant from the American Bankers Association, is to analyze and quantify the behavior patterns of individual commercial banks during a period containing several very sharp changes in monetary policy. The first part of the study shows how these changes in policy altered the distribution of funds among the different types of banks, and how changes in fund flows combined with differences in bank response altered the supply of bank credit to different types of borrowers and to different parts of the country.

The second part of the study develops a microeconomic model of bank behavior and then uses regression analysis on the cross-section data to implement this model. The regression results focus on the individual bank's response to changes in available funds and in the demand for bank credit.

Most of the data manipulation and regression analysis have been completed. The major remaining tasks are the detailed analysis of the empirical results and the preparation of the manuscript.

David T. Kresge

6. STUDIES IN INDUSTRIAL ORGANIZATION

ECONOMICS OF HEALTH

The National Center for Health Services Research and Development has renewed its support of the health economics program for an additional four years. A principal objective of the new research is to throw light on the factors affecting the cost of medical care through analyses of prices and utilization. The study of prices leads to investigations of productivity and earnings, while the question of utilization involves consideration of health insurance, changes in the art of medicine, and numerous identifiable components of "taste." We also continue to be concerned with the broad determinants of health including but not limited to medical care.

Michael Grossman has completed his study of the demand for health and Morris Silver has completed his analysis of mortality differentials. One or both of these studies will appear, along with a collection of earlier papers, in a volume of Essays in the Economics of Health and Medical Care.

Since the last *Annual Report*, the following publications have appeared:

Victor R. Fuchs, Elizabeth Rand, Bonnie Garrett, "The Distribution of Earnings in Health and Other Industries," *Journal of Human Resources*, Summer 1970. In addition, Morris Silver, Michael Grossman, and I have contributed papers or comments to *Empirical Studies in Health Economics*, Herbert Klarman, ed., Johns Hopkins University Press, 1970.

In November I presented a paper "A Framework for Determining the Costs of Alternative Plans for National Health Insurance" at a Conference on National Health Insurance at the University of Pennsylvania.

Michael Grossman and I have completed a draft of a paper, "The Correlation Between Health and Schooling." Marcia Kramer and I have completed a draft of a paper on expenditures for physicians' services (reported on below).

Dr. Kurt Deuschle, Chairman of the Department of Community Medicine, Mount Sinai School of Medicine has assumed the chairmanship of our advisory committee; other members are: Morton D. Bogdonoff, M.D.; James Brindle; Norton Brown, M.D.; Eveline Burns; Philip Enterline; Marion Folsom; Eli Ginzberg; George James, M.D.; Richard Kessler, M.D.; David Lyall, M.D.; Jacob Mincer; Melvin Reder; and Peter Rogatz, M.D.

Victor R. Fuchs

Expenditures for Physicians' Services in the United States, 1948-68

The principal objective of this study is to identify the determinants of expenditures for physicians' services. This is done through an examination of changes in national aggregates over time and an econometric analysis of variations across states in a single year, 1966.

The basic data on expenditures are from the Internal Revenue Service and refer to the gross receipts from medical practice of self-employed physicians. For analytical reasons, our concern is with the price and quantity of physicians' services. A major problem has been that the relevant series are unavailable either longitudinally or cross-sectionally, and thus we have had to estimate them.

For the time series, our estimate of average price received (AP) is based on the physicians' fee component of the consumer price index, adjusted to take account of differences between nominal fees and those actually charged and differences between fees charged and fees received. We assume that the physician is more likely to charge his customary fee, and more likely to collect his charges, when the service is reimbursed by insurance.

No data at all exist on price differences among states. Here, the breakdown of expenditures between price and quantity is based on the direct estimation of quantity. Data from the 1966-67 National Health Survey on outpatient visits by geographic area are adjusted to reflect (1) the degree of physician specialization in each state, and (2) the number of hospital inpatient visits of private physicians

in each state (estimated from statistics on patient-days). The fundamental assumption is that visits by specialists represent a greater quantity of service than visits by GPs, and, similarly, that inpatient visits represent more service than outpatient visits. In both cases the weights used are the ratio of average charges for the different categories of services.

Part I of our paper distinguishes three subperiods, 1948-56, 1956-66, and 1966-68. The average annual growth of expenditures was not only high over the two decades but rapidly rising. Most of the growth could be accounted for by changes in *AP* and population, but the growth in real per capita terms (Q^*) also showed a marked acceleration. Explaining this was one of our major objectives. The conventional demand variables—income, price, and insurance coverage—changed at roughly the same rates in 1948-56 and in 1956-66 and thus cannot be the source of the sharp upsurge during the second period.

In our view, the demand shift is primarily attributable to changes in medical science. The late 1940's and early 1950's were marked by the introduction and widespread diffusion of many new drugs extremely effective against infectious diseases, which had previously played a large role in mortality and morbidity. Since the mid-50's the advances that have occurred have typically been of a kind that make only marginal improvements in broad health indexes, although they may have pronounced effects on individual patients. The differential health impact of medical advances in these two periods can be inferred from changes in mortality rates: deaths per 100,000 fell by 5.1 per year from 1948 to 1956, but have remained quite stable since then. Furthermore, the early advances tended to be physician-saving in terms of the man-hours required to implement them, this being another reason why the demand for physicians' services should then decline. Advances of the later years were characteristically physician-using, and because their health impact was so much less dramatic, the result was a rapid growth in demand. Support for our hypothesis concerning the relative physician-intensive-ness of medical practice is to be found in the average length of hospital stay: from 1948 to 1956 it fell from 8.7 days to 7.7 days; after 1956 it leveled out and then rose to 7.9 in 1966.

The cross-sectional analysis in our paper utilizes a comprehensive model of the market for physicians' services. In particular, we hypothesize that physicians, because of the high degree of trust vested in them by consumers lacking specialized knowledge, are able to exercise a *direct* influence on demand, apart from their effect on price. We also explore the possibility that nonpecuniary motivations have a bearing on physician productivity, with a sense of professional responsibility motivating the individual physician to provide additional services when he is in an area poorly endowed with medical personnel.

Weighted, logarithmic regression equations are estimated by means of two-stage least squares. Support is found for the hypothesis that insurance operates on demand by lowering the price of medical services as perceived by the patient himself: price, net of insurance benefits, proves to be a stronger demand variable than the average price received by physicians, though in either specification a low demand price elasticity is observed. Physicians, who enjoy a wide margin of discretion in recommending follow-up visits and determining the diagnostic and therapeutic course to be followed, are indeed able to generate a demand for their services. A contributing factor here may be that, as average queuing time decreases, the total price to the patient, including the value of his time, is diminished. Neither health, race, education, age structure, or alternative sources of supply (other than private practice physicians) has a significant effect on demand. The \bar{R}^2 in the best demand equation is .74.

Medical schools, hospital bed supplies, price, and per capita income are the principal factors influencing physicians in their locational decisions. Income serves as a taste variable in this regression, with the cultural, social, educational, and recreational opportunities available in high-income states apparently exercising

a powerful force on physician location. No evidence is found for the thesis that physicians are drawn to areas of high medical need, or that the state of origin of physicians prior to their entry into medical school exerts any discernable influence on location.

The decision to purchase medical insurance under conditions of uncertainty is seen to be far more sensitive to economic considerations than the decision to purchase medical care. The income elasticity of benefits per capita is 1.0, while the price elasticity of demand is on the order of -1.2 . Labor union membership, as expected, increases the level of insurance benefits in a state.

Other things being equal, we find that variations in Q^* and in number of physicians per capita have virtually no impact on either the crude death rate or the infant mortality rate, our two measures of health status. Over the range of interstate variation in physicians' services, differences in quantity per capita do not seem to make much difference in mortality.

The most significant conclusion of this study is that supply factors (technology and number of physicians) are of over-riding importance in determining the utilization of and expenditures for physicians' services. This conclusion stands in sharp contrast to the widely held belief that utilization and expenditures are determined by the patient, and that information about income, insurance, and price is sufficient to explain and predict changes in demand. Estimates of future "needs" for physicians are likely to be unreliable unless one can predict the nature and extent of future changes in medical science. Also, because physicians to a considerable extent determine demand for their own services, increases in supply are not likely to put much downward pressure on price but would sharply increase expenditures. Given present patterns of distribution of physicians, the effect on health would probably be small.

Victor R. Fuchs
Marcia J. Kramer

The Correlation Between Health and Schooling

Several recent studies in the United States indicate that, among socioeconomic variables, years of schooling is probably the most important correlate of good health. This finding emerges whether health levels are measured by mortality rates, morbidity rates, or self-evaluation of health status, and whether the units of observation are individuals or groups. The relationship is usually statistically significant (at $p = .05$ or better) in both simple and partial correlations. The purpose of this project is to test alternative explanations of this correlation empirically in order to select the most relevant ones and to obtain quantitative estimates of different effects.

Explanations of the positive correlation between health and schooling may be put into one of three categories. One set of explanations argues that the causal relationship runs from increases in education to increases in health. The second category argues that the direction of causality runs from better health to more education. The third category argues that no causal relationship is implied by the correlation. Instead, differences in one or more "third variables" affect both health and education in the same direction.

Increased schooling might lead to better health because schooling might make an individual a more efficient "producer" of health. Another possibility is that the higher wages associated with more schooling imply that the rate of return for each additional healthy day will be greater for the more educated. This might give them a greater incentive to invest in their health. Healthier students might have a greater incentive to invest in education because the costs of this investment might be lower for them. Healthier persons might be more productive students, which would produce a positive correlation between health and academic performance and a negative correlation between health and the cost per unit of knowledge. Costs might also fall as health rises because healthy students with

good high school academic records have a better chance of being admitted to outstanding colleges and of acquiring scholarships or other financial aid for college education.

Potential third variables for explaining variations in health and education simultaneously include race or religion, parents' education, genetic or biological factors, and parents' income. Some religious or racial groups might value the consumption aspects of health and education more highly than other groups. Therefore, they would devote a larger fraction of their budgets to these ends. Well-educated parents might be more efficient producers of healthy and well-educated children. Since production costs are lower, they would have an incentive to produce such children. Several studies indicate that certain genetic factors play a major role in determining both health and intelligence quotient. Since students with higher IQ's are likely to attend school for longer periods of time, variations in IQ might be employed as a proxy variable to explain variations in health and education simultaneously. Since both health and education can be viewed as components of the stock of human capital, variations in the two variables might be traced to capital market conditions that cause the quantity of investments to differ among individuals. One possibility is that children from high-income families probably have lower explicit or implicit borrowing costs than those from low-income families. This would induce the former group to make larger investments in health and education.

It should be noted that the three explanations of the correlation between health and schooling are not mutually exclusive. But from the point of view of public policy in the health area, it is important to distinguish among the three explanations and to obtain quantitative estimates of their relative magnitudes. For example, a stated goal of public policy in the United States is to improve the level of health of the population. Given this goal and given the high correlation between health and schooling, it might appear that one method of implementing it would be to increase government outlays on education. In fact, Auster, Leveson, and Sarachek suggest that the rate of return on increases in health via higher education outlays far exceeds the rate of return on increases in health via higher medical care outlays.¹ This argument assumes that the correlation between health and education reflects only the effect of education on health. If, however, the causality ran the other way or if the third variable hypothesis were relevant, then increased outlays on education would not accomplish the goal of improved health.

To test competing explanations of the health-education correlation, I will first utilize data in the NBER-Thorndike sample. In 1955, Thorndike collected income, education, and occupation information for nearly 10,000 persons who took the air cadet qualifying examinations in 1943; and in 1969 the National Bureau re-sampled these individuals. The Bureau obtained two health indexes for 1969: self-evaluation of health status and sick time. In addition, the persons who died between 1955 and 1969 can be identified. With these data, it will be possible to test the third variable hypothesis against the other two explanations of the health-education correlation. It may not, however, be possible to determine the direction of causality implied by a significant relationship between these two variables. Potential third variables include parents' education and occupation, religion, and test scores on the air cadet qualifying examinations. It is hoped that the test scores will provide an accurate index of intelligence quotient.

The optimal way to measure the net impact of education on health and the net impact of health on education would be to obtain data for a cohort of persons of the same age over time. With such data, the number of years of formal schooling could be related to indexes of health at young ages and to third variables. Moreover, the effect of education on health status at post-school ages can be examined

¹ Richard D. Auster, Irving Leveson, and Deborah Sarachek, "The Production of Health, an Exploratory Study," *Journal of Human Resources*, Fall 1969, p. 434.

in detail. One potential data source for performing such experiments is the collaborative study of 50,000 births that is being conducted by the National Institutes of Health. This study traces a cohort from birth through childhood and contains measures of health and intelligence at various points in time as well as information concerning the socioeconomic characteristics of parents. At a later stage in the project, I hope to analyze this data in detail.

Michael Grossman

Surgical Workloads

The physician shortage is one of the most highly publicized of medicine's many problems. To counteract it, many organizations and individuals are calling for a drastic increase in the number of our nation's doctors. Little attention has been paid to possible inefficient utilization of the existing number of doctors, although the high costs of medical and specialty training make this possibility important.

One of the specialties with alleged underutilization is general surgery. Some physicians claim that there are too many general surgeons and that the existence of "excess capacity" tends to result in unnecessary surgery. This study examines the operative workload of a population of nineteen general surgeons, all practicing in a voluntary nonprofit hospital in suburban New York. In order to calculate summary measures of surgical work it is necessary to weight different types of operations. We use the California Relative Fee Scale for weighting purposes. This scale, which reflects the average customary fee reported by California physicians, proves to be highly correlated ($r = .97$) with average operating room time for twenty-seven different procedures at a large New York City teaching hospital. Thus, the weights are nominally price weights, but can alternatively be regarded as indicating relative inputs of time.

The unilateral adult inguinal herniorrhaphy, which is one of the most common procedures performed by general surgeons, is given a weight of 1.0 and all others are expressed in terms of "hernia equivalents." Information about each hospital operation performed by each surgeon during a recent twelve-month period was obtained from hospital records. Because all the surgeons had multiple hospital appointments, it was necessary to obtain records from seven institutions.

Table II-4 (p. 128) shows that the variation in workload is extremely large. The busiest surgeon does 13.0 hernia equivalents per week; the median surgeon only 3.1 (assuming forty-eight weeks of work per year). The average complexity of operation, measured by the mean hernia equivalent per operation, also varies among surgeons, but by much less. The final column shows the extent of variation of complexity of each surgeon's workload.

It is difficult to state with precision what constitutes "capacity," but a sampling of professional opinion suggests that ten hernia equivalents per week would constitute an active but not unreasonable workload for a general surgeon. Thus we see that most surgeons in the population studied probably have considerable "excess capacity."

We are currently analyzing variations in workload and complexity of practice in relation to surgeon characteristics such as age, number of affiliations, and professional accreditation. We are also looking at variations in complexity across hospitals classified by size and type of control (voluntary vs. proprietary).

Further research contemplated includes studies of the above population to learn how nonoperative time is spent and surveys of large regional or national groups of general surgeons to determine the extent and pattern of excess capacity. The method developed in this project lends itself to such survey analysis and to further field studies on other specialists. It is anticipated that this study and the proposed studies will have implications for medical education, general surgical training, and the organization of medical care.

Victor R. Fuchs
Edward F. X. Hughes

TABLE II-4
Annual Number of Operations and Hernia Equivalents, By Surgeon

Surgeon	Annual Number of Operations	Number of Operations with Secondary Procedure	Annual Number of Hernia Equivalents ^a	Weekly Hernia Equivalents ^b	Mean Hernia Equivalent per Operation	Standard Deviation of Mean	Coefficient of Variation
A	569	131	625	13.0	1.10	.63	56.91
B	562	128	460	9.6	.82	.59	71.98
C	451	52	353	7.4	.78	.57	73.40
D	275	48	296	6.2	1.08	.65	60.03
E	300	67	278	5.8	.93	.65	69.66
F	274	46	266	5.5	.97	.57	58.57
G	249	46	245	5.1	.98	.62	62.96
H	177	56	191	4.0	1.08	.70	64.58
I	178	21	176	3.7	.99	.68	68.53
J	121	22	147	3.1	1.22	.63	52.21
K	165	25	143	3.0	.87	.63	72.64
L	139	21	129	2.7	.92	.63	68.39
M	133	18	122	2.5	.92	.61	65.99
N	121	51	116	2.4	.96	.71	73.47
O	127	19	111	2.3	.88	.55	62.80
P	136	83	111	2.3	.82	.67	81.29
Q	98	23	92	1.9	.94	.62	66.71
R	47	8	48	1.0	1.01	.73	72.35
S	56	35	43	0.9	.77	.33	42.84
Total	4,178	900	3,952				
Mean	220	47	208	4.3	.95		
Median	165	46	147	3.1	.94		
Weighted mean ^c					.96		

^a Primaries + .2 secondary procedures.

^b Based on a 48-week year.

^c Weight = annual number of hernia equivalents.

Economic Analysis of Accidents

Accidents are the fourth leading cause of death in the United States. In addition, they impose significant personal and property losses. The allocation of scarce resources to accident prevention and the care of victims should reduce the expected losses from accidents. This study is proceeding along several lines.

1. A theoretical model is developed that identifies the factors affecting the amount of resources allocated to reducing expected accident losses. These include the productivity and costs of safety devices, the initial probability and anticipated losses from an accident, the individual's wealth, the price of market insurance, attitudes toward risk, and the type of liability rule set by the legal system.

2. An empirical analysis is planned of specific accidents, including automobile accidents, using both cross-sectional data for states in 1960 and changes over time for the United States as a whole. Since most of the data can be disaggregated into age, sex, and color groups, we will investigate differences among these groups. Some of these differences are illustrated in Table II-5. We observe a more rapid

TABLE II-5
Deaths from Accidents Per 100,000 Persons
By Age in the U.S., 1959-61

Type of Accident	Age Group	Whites		Nonwhites	
		Males	Females	Males	Females
All, excluding automobile	15-24	29.6	4.1	46.6	8.1
	25-34	28.9	5.3	52.4	12.9
	35-44	31.7	6.5	55.9	17.8
	45-54	41.3	10.1	75.0	20.3
	55-64	49.6	14.3	82.5	32.0
Automobile accidents	15-24	62.8	15.2	49.2	11.8
	25-34	38.5	9.3	51.4	11.4
	35-44	28.6	9.0	44.4	11.3
	45-54	30.1	11.4	47.7	12.6
	55-64	34.2	14.9	48.3	13.8

rise with age of nonautomobile accidents for females (both whites and nonwhites) compared with males, substantially higher death rates from nonautomobile accidents for nonwhites than whites, and the absence of a peak in automobile death rates at ages 15-24 for nonwhites.

3. An empirical analysis of the effects of liability rules on accidents is being undertaken. To do this one must identify differences either in a cross section or over time in liability rules for particular types of accidents. There are some differences across states in the way the fault standard of liability is administered for automobile accidents, and liability in industrial accidents has changed over time from one of fault to one of absolute liability of the employers. We intend to investigate railroad and mining accidents.

William Landes

The Effects of Legalized Abortion in New York

Since July 1, 1970, abortion has been legal in New York State through the twenty-fourth week of pregnancy. The principal purpose of this study is to determine the effect of the new law on fertility, on illegitimacy, and on maternal and infant mortality. I also plan to investigate its impact on public assistance (aid to dependent children and aid to unwed mothers), marriage (the rate and the average age at time of marriage), education (dropout rate), adoption, and on the health sector itself.

The econometric analysis will be performed on two levels of aggregation: on a county basis for the state, and a health area basis for N.Y.C. (the Health Department recognizes 350 distinct health areas). Fourth-count summary tapes from the 1970 Census will be available shortly for each of these geographic areas. Vital statistics data, also on tape, will be obtained from Health Department records.

The determinants of the fertility rate will be analyzed in the year preceding passage of the law and then again in the year commencing nine months after passage. Comparison of regression coefficients from the two cross sections will, with adjustment for trend, indicate the degree to which the impact on fertility of a large number of demographic and socioeconomic population characteristics has been affected by the new law. As legalization of abortion serves to strengthen the correspondence between actual and desired fertility, the post-reform situation will, in itself, provide an unparalleled opportunity to investigate the determinants of the demand for children.

Marcia J. Kramer

Differences in Male and Female Mortality Rates in the United States

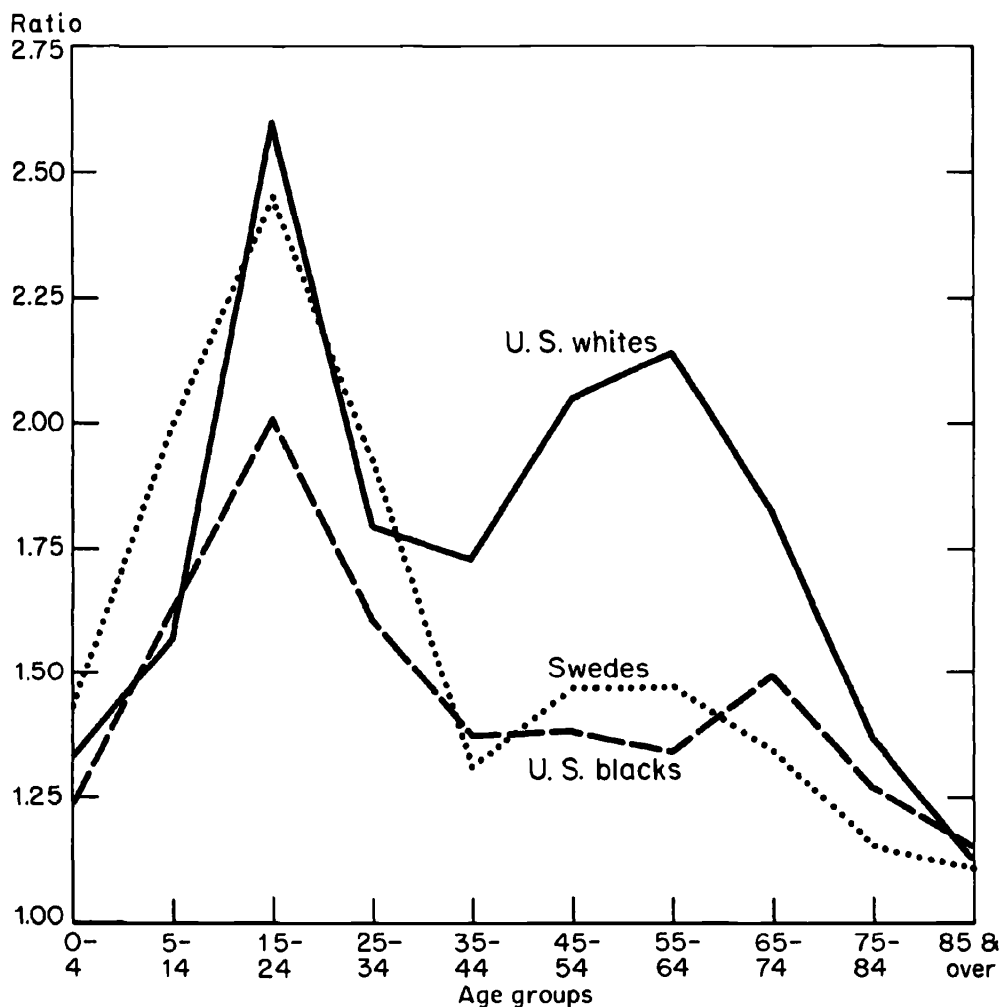
In the United States, as well as in other westernized societies, women enjoy a longer life span than men. The differential in mortality rates in the United States is particularly noticeable during the economically most productive decades of life: recently for whites the male death rate was 1.7 times the female at ages 35-44, 2.0 at ages 45-54, and 2.1 at ages 55-64. Thus, the substantial female mortality advantage has significant economic implications.

To date, essentially two hypotheses, a biological and an environmental or "stress" hypothesis, have been advanced to account for the excess male mortality. However, advocates of each hypothesis have been unable to demonstrate the superiority of their particular position using the data sets they have examined. This is because over the past seven or eight decades nearly complete eradication of mortality from infectious diseases has been achieved simultaneously with the rapid development of modern industrial society. Thus, advocates of the biological hypothesis have attributed the substantial female advantage which emerged over this period to the unveiling of the true biological survival potential of the two sexes previously obscured by the high mortality rates of both sexes from infectious illnesses. Environmentalists have stressed the particular role differentiation which emerged as a result of the increased complexity of modern society.

To shed some light on this problem, I have focused my attention on a cross section of U.S. male/female age-specific mortality ratios for the years 1959-61. Using a sample of the ninety-nine largest SMSAs for whites and fifty-nine SMSAs for blacks, Chart II-1 shows that black males do not experience a deterioration in their mortality status relative to their female counterparts during their middle years, such as is the case for whites. The Swedish male/female death rate ratio profile indicates that this difference between blacks and whites need not be due to biological differences or the generally poorer health status of blacks in the United States relative to whites. Here, then, is some evidence that socioeconomic forces may be responsible for the size of the male/female mortality differential.

Subsequently, the data were analyzed using multiple regressions across SMSA's, with city size and two regional variables (South and West) as the independent variables. These simple equations had considerable power in describing the mortality experience of whites ($\bar{R}^2 = .46$ for the 55-64 year group) but no significant results emerged from fitting the same equations to the black sample. For the age groups beginning at 15-24 and running through 85 and over, a significant negative correlation was uncovered between city size and the age-specific male/female mortality ratio for whites. In addition, the male/female ratio was found to be significantly higher in the South for most of these age categories, while the results for the West were inconclusive. Subsequent analysis of the individual sex groups indicated that these variations in the male/female ratio were largely the result of

Chart II-1
 The Male/Female Death Rate Ratio Profiles for
 U.S. Whites and Blacks (1959-61) and Swedes (1960)



a significant deterioration in the actual mortality status of women as city size increased. Also, males of working age in the South had above-average death rates, while females tend to do better in the South than in the rest of the nation.

When these results are interpreted in light of Fuchs' findings about male/female wage rate differentials, they appear to add additional support to the environmental hypothesis. Fuchs found that the difference between the wage rate of males and females declined as city size increased, and that it was larger in the South than in the rest of the nation (this was after taking account of the variation in the wage rate due to age, occupation, sex, race, and education). As it is possible to interpret such changes in the wage rate differential as indexes of the variations in the socio-economic roles and status of the two sexes, it seems likely that the poor relative mortality status of males in the U.S. is at least partly due to the socioeconomic roles they assume, and that as females move into similar positions their health status deteriorates relative to males.

Eugene Lewit

HORIZONTAL MANUFACTURING CARTELS IN SWEDEN AND DENMARK

Students of market structure have debated for some years the stability and effectiveness of agreements to increase industry profits by producers in industries with few firms. Cartel agreements are legal and enforceable in Denmark and Sweden,

and they are registered with the government in both countries. This makes the cartel registers a potentially useful source of primary data. Coded summaries of horizontal agreements between manufacturers have been prepared, containing information on number of parties to the agreement, products covered, date the agreement was made (and terminated if discontinued), main substance of agreement, mechanism for detecting violations, and mechanism for enforcing and punishing violators. There are approximately 400 Swedish and 450 Danish agreements. From Sweden, it was also feasible to obtain some data on industrial structure, rates of return, and time series of prices.

These materials should make possible the testing of a number of hypotheses on cartels, with extensive coverage of the manufacturing sector.

John C. Hause

DIVERSIFICATION IN AMERICAN INDUSTRY

The principal activity on this project during the past year was a further refinement of basic data and the preparation of a paper (jointly with S. Arora and R. McGuckin) entitled, "Firm and Industry Aggregates in the Analysis of Diversification and Integration." The paper was presented at the National Bureau's Workshop on the Use of Microdata Sets in Economic Analysis, held in Washington, D.C., in October 1970. This paper examines the degree of similarity in diversification patterns among firms classified by primary industry. It also assesses the role of vertical integration in the nonprimary activities of companies.

Work on the preparation of a manuscript for the entire project will resume this summer. It will be concerned with three questions: What are the forces that explain entry rates into markets for new products? What is the relative importance of individual company versus industry characteristics in explaining diversification? What have been the trends in diversification since 1954 as judged by aggregative census data?

Michael Gort

7. INTERNATIONAL STUDIES

INTRODUCTION

One of the most topical studies undertaken in the international area is Michael Michaely's *The Responsiveness of Demand Policies to Balance of Payments: Post-war Patterns*, published in March 1971. His review of the patterns of demand policy in leading countries suggests that the assumptions underlying the functioning of a fixed exchange-rate system have not been borne out by the experience of recent years.

Another study recently published, that by Kravis and Lipsey on *Price Competitiveness in World Trade*, constitutes one of the National Bureau's major efforts in data gathering and analysis. It is hoped that this study will lead to the adoption of improved methods of international price measurement by national and international statistical agencies, once there is adequate awareness of the unreliable nature of the various proxies, such as unit value indexes, typically employed in international price comparisons. Kravis and Lipsey report below on further analytical work using their new data and other series to study the role of prices in international trade.

Still another study very relevant to the current international scene is that now nearing completion by Furth and Mikesell on foreign holdings of liquid dollar assets. The need to know more about the nature and purposes of these holdings has increased with the rapid growth both of direct dollar claims on the United States and of claims among foreigners in the form of Eurodollar balances. Furth and Mikesell have extended their work to take account of important new data and of recent shifts in the pattern of dollar holdings.

Lipsey and Weiss note in the report on their work on foreign direct investment and trade that encouraging progress has been made in overcoming the problems of coordinating data from a variety of government and private sources. Substantive results should soon begin to emerge on the relation between U.S. investment in manufacturing abroad and U.S. exports.

Walther P. Michael's monograph on "Measuring International Capital Movements" will shortly be published. This study, covering the first half of the 1950's, is in the nature of an experiment in deriving matrices of capital flows on the basis of the partial data available from both capital-supplying and capital-receiving countries.

The trade and development problems of the less developed countries have stimulated an intensive and far-reaching project, financed by the Agency for International Development, focusing on the foreign exchange policies and problems of these countries. This project is directed by Bhagwati and Krueger and, as they report below, is participated in by a number of other leading scholars—here and abroad—with first-hand experience in the countries studied. Seiji Naya is continuing his research on the trade problems of countries of the Pacific area.

As its part in a project on the diffusion of technology carried on in collaboration with five European research institutes, the National Bureau is well along in testing a model designed to explain the rate of diffusion of the basic oxygen process in steelmaking in the United States and other countries. Further details are given in the report by Guy Herregat and John R. Meyer.

Portions of a draft by George Garvy on the functioning of the banking and credit system in the Soviet Union are in the hands of a staff reading committee, and the rest of the draft is expected to be ready for review shortly.

Hal B. Lary

THE ROLE OF PRICES IN INTERNATIONAL TRADE

Despite the central role accorded to prices in the theory of international trade and in the functioning of the international monetary system, the price indexes used in analyses of trade have been seriously deficient. Their defects may have introduced

large biases and random errors into measures of the effects of price changes and into policy judgments on the effects of inflation and of tariff, income, or exchange-rate changes.

Using the price data collected for our recently published book on *Price Competitiveness in World Trade*, and several other new collections or recomputations of price information we consider more appropriate than those previously available, we plan to study the relation of trade flows to price changes and to compare our results with those previously obtained by others.

Our indexes from the price competitiveness study cover machinery, transport equipment, metals, and metal products for the United States, the United Kingdom, Germany, and Japan in the years, 1953, 1957, and 1961-64. In addition, we have annual indexes for 1953-68, calculated from wholesale prices for the same groups of commodities, reweighted to provide comparability among the different countries in coverage and weighting, thus correcting one of the serious deficiencies of the indexes usually employed in studies of international trade. In addition to analyzing total exports of the four countries by both large and more detailed commodity groups, we will examine competition in fourteen individual markets to eliminate some of the effects of differences among markets in the response to price changes.

An early report on this study was presented in a paper on International Comparisons of Prices and Real Incomes, given at the May 1970 Conference on Research in Income and Wealth. A report on further progress will be presented at a conference in October 1971 on The Role of the Computer in Economic and Social Research in Latin America. The data collection and processing during the past year have been done mainly by Marianne Lloris and Christine Mortensen at the National Bureau and Lorenzo Perez at the University of Pennsylvania.

Irving B. Kravis
Robert E. Lipsey

FOREIGN HOLDINGS OF LIQUID DOLLAR ASSETS

With the benefit of data not previously available, we have revised our estimates of the gross and net liquid dollar positions of foreigners, including both liquid dollar claims and liabilities of foreigners vis-a-vis U.S. residents (American dollars) and dollar-denominated liquid claims and liabilities among nonresidents (Eurodollars).

Given the growth of the Eurodollar market in recent years, we have deemed it useful to try to formulate a method for determining the amount of and the year-to-year changes in foreign dollar liquidity represented by Eurodollar deposits. Our formulation follows the approach of the BIS staff in excluding interbank Eurodollar deposits, but our estimates of the volume of foreign dollar liquidity represented by Eurodollar deposits are somewhat lower than the BIS estimates of the net size of the Eurodollar market.

The existence of a large volume of liquid dollar obligations among foreigners complicates the problem of analyzing the factors determining the foreign non-official demand for liquid dollar assets and, hence, the analysis of private short-term capital movements in the U.S. balance of payments. We have formulated in general terms a portfolio model for determining the foreign demand for the two categories of liquid dollar assets—American dollars and Eurodollars—and have sought to relate our estimates of foreign liquid dollar holdings over the 1964-69 period to our model.

One of our conclusions is that the large growth of international transactions denominated in dollars in recent years has not been accompanied by an increase in the foreign transactions demand for liquid American as contrasted with Eurodollar assets. The huge size of foreign holdings of demand deposits and other liquid assets in the United States, as published by the U.S. Treasury Department, may be misleading in this regard. Of the foreign nonofficial holdings of American

liquid dollar assets at the end of 1969, nearly two-thirds represented obligations of U.S. banks to their foreign branches and obligations of the American branches and agencies of foreign banks to their head offices and branches abroad. At the same time, probably half of all Eurodollar deposits are held with foreign branches of U.S. banks. These facts emphasize the importance of intrabank relations for the Eurodollar market, which is to a considerable degree an extension of the U.S. banking system.

Finally, we have formulated a model for determining the effects of Eurodollar market operations on foreign holdings of American liquid dollar assets and have tested this model by means of regression analysis. This analysis relates quarterly changes in U.S. liquid dollar liabilities to nonofficial foreigners and in U.S. liquid dollar liabilities to foreign official agencies as the dependent variables, and quarterly changes in selected assets and liabilities of foreign branches of U.S. banks as the independent variables. Further quantitative analysis of this type will be facilitated by the forthcoming publication of additional data on assets and liabilities of foreign branches of U.S. banks by the Federal Reserve Board.

J. Herbert Furth
Raymond F. Mikesell

EXCHANGE CONTROL, LIBERALIZATION, AND ECONOMIC DEVELOPMENT

This project is concerned with the widespread phenomenon of exchange control in less developed countries, the effects of these controls on their economic growth, and the possibilities of shifting to less restrictive regimes. Eleven country studies have been undertaken, each by an economist already familiar with the country concerned. The countries and authors are as follows: Brazil, Albert Fishlow; Chile, Jere Behrman; Colombia, Carlos F. Diaz-Alejandro; Egypt, Bent Hansen; Ghana, J. Clark Leith; India, Jagdish N. Bhagwati and T. N. Srinivason; Israel, Michael Michaely; Pakistan, Nurul Islam; Philippines, Robert E. Baldwin; South Korea, Charles Frank; and Turkey, Anne O. Krueger.

In addition to being of interest in their own right, the country studies are to serve as a basis for a general synthesis by the co-directors, Bhagwati and Krueger. To provide coordination of the studies, an "analytic framework" was prepared and reviewed at the initial working party in May 1970. Further working papers deal with such topics as the agreed common ground to be covered by the studies and the techniques of measuring implicit foreign exchange rates for different products or product groups.

Work has been started on all of the country studies, and progress was reviewed at a second working party in June 1971. Our schedule calls for all of these studies to be ready in preliminary draft for a third working party early in 1972, to be followed by completion of the studies and the general synthesis.

Jagdish N. Bhagwati
Anne O. Krueger

THE RELATION OF U.S. MANUFACTURING ABROAD TO U.S. EXPORTS

This study has as its main purpose the analysis of the effect on U.S. exports of manufacturing investment and production abroad by American companies. In the past year, a unique body of information on the foreign and domestic activities of American companies has been assembled. Government data on the country of operation, industry, sales size, capital expenditures, financing, and trade of each of several hundred parent companies and several thousand affiliates have been linked, on an individual company level, to information from other sources on the finances, level and industrial distribution of employment, and other characteristics of the U.S. parent companies. The combined data set must be processed within the government to protect the confidentiality of individual company reports. The Bureau of the Census has begun the computer processing, and we should soon be able to prepare at least a preliminary report on the study.

Concurrently with these operations, we are preparing, with the aid of a large number of American parent companies, another set of data giving the industry and product characteristics of American affiliates in foreign countries. To take advantage of this more detailed classification, these data will be added to the set processed in Washington, and will also be available for work at the National Bureau on this and related studies. We expect to have these data for more than two hundred parent companies and several thousand affiliates.

As a by-product of our search for the factors affecting the flow of trade, we have been investigating the determinants of ocean transport cost for different commodities. We have related transport cost per ton to the length of voyage, the size of the shipment, the unit value (value per ton) and the stowage factor (bulkiness) of various commodities. Other factors to be examined are the direction of the shipment and the fragility of the product. The data for this project were gleaned from the Bureau's earlier study of international price competitiveness and from a Census Bureau study of transport costs on U.S. imports. We expect soon to complete a paper giving equations for estimating transport cost on a wide range of commodities.

The company and affiliate data collected for the direct investment study, in combination with additional information soon to be available from the 1966 Census of Direct Investment conducted by the Office of Business Economics, are a valuable resource which should be exploited not only for further work on the effects of investment on trade but also for the investigation of a wide variety of other topics. These include the impact of investment on the international division of labor and on the economies of host countries, and the motivation for investment and its effect on the investing country and company. Other studies might use the same data to examine the response of companies to international differences in production conditions and legal circumstances, and the role of intracompany flows of technical knowledge via skilled personnel and licensing and patent arrangements. We hope to widen the scope of the Bureau's inquiries into the international firm after the completion of the present study.

This project has been financed by grants from the Ford Foundation and the National Science Foundation. Beatrice Grabiner, Doris Preston, and Susan Tebbetts have been mainly responsible for data collection, computer processing, and the surveying of American companies during the past year.

Robert E. Lipsey
Merle Yahr Weiss

THE DIFFUSION OF NEW TECHNOLOGIES

Since 1968 the National Bureau has been participating with a group of European Research Institutes in an international study of the diffusion of several major technological innovations. In addition to providing the other institutes with the U.S. national and firm data related to the particular processes they are studying, the National Bureau has been conducting an analysis of the speed of diffusion of the basic oxygen process in steelmaking in this and other countries.

The untimely death of Alfred H. Conrad last October delayed the scheduled completion of the Bureau's contribution; termination date has now been fixed for the fall of 1971. John Meyer has assumed Conrad's responsibilities in the project.

During the past year, the European institutes collected answers to the questionnaires they had distributed and presented preliminary drafts on special presses in papermaking (Industriens Utredningsinstitut, Stockholm), shuttleless looms in textiles (National Institute for Economic and Social Research, London), and continuous casting in steelmaking (Osterreichisches Institut fur Wirtschaftsforschung, Vienna). Papers on numerically controlled machine tools (IFO-Institut fur Wirtschaftsforschung, Munich) and tunnel kilns in brickmaking (Istituto per lo Studio della Congiuntura, Rome) are near completion.

At the National Bureau, organization of the data collected from firms respond-

ing to the steel questionnaires was completed; while the diffusion model was further specified and modified. Although the model we are using remains basically the same as the one presented here last year by Alfred Conrad, it has now been simplified, due to estimation difficulties, and is being tested in two stages. The first stage is an accelerator-residual funds investment function for the steel industry. The second stage relates introduction of the oxygen steel process to the investment path, the national availability of scrap, and average plant size.

With respect to the first stage, preliminary results of cross sectional and time-series regressions show that availability of funds seems to be the dominant factor in steel companies' investment decisions. For the second stage, the oxygen steel process equation, the explanatory variables generally have the expected sign, including those often neglected in earlier studies on the diffusion of the technology. In the cross-sectional regressions, the adjusted R^2 's are generally close to .80, and in the time-series and pooled regressions they are in the .60 range.

The differences in the results between cross-sectional and time-series estimation can be explained either by scale differences in the size of national steel industries or by differences in national diffusion targets. If the target difference is the explanation, this would imply that, in the cross-sections, investment is determined by BOP diffusion. To test for this possibility, we have also run the BOP diffusion function with current investment included as an explanatory variable, using a two-stage least squares estimation technique.

The remaining unexplained variance for oxygen process adoption, as expressed by the second stage residuals, will be treated as a new dependent variable in a managerial profile analysis. First, though, principal components analysis will be applied to the whole set of the financial data of some 150 firms, the data for which have been extracted from reworked balance sheets and income statements published by the High Authority of the European Coal and Steel Community, covering non-member as well as member countries. It is hoped that this procedure will evidence some clusters of firms corresponding to distinct behavioral types and will allow us to identify national profiles or characteristics. Estimation of how much of the remaining variance in the oxygen steel diffusion model can be explained by international differences in managerial behavior patterns will conclude the analysis.

During the past year the project has benefited from the research assistance of Neville O. Beharie and Pamela Mash.

Guy Herregat
John R. Meyer

MONEY, CREDIT, BANKING, AND FINANCIAL FLOWS IN EASTERN EUROPE

In view of the scope of the project as outlined in the last *Annual Report*, it was found advisable to split it into two volumes, one on the Soviet Union and the other on the other countries of Eastern Europe.

The manuscript of the first volume is virtually completed. The first two parts, a general historical introduction and an analysis of the standard system, are already in the hands of a reading committee. The drafting of the third part, which deals with the financial aspects of the reforms initiated in 1965, is nearing completion.

It is not certain how rapidly progress can be made on the second volume.

George Garvy

8. MEASUREMENT METHODS AND OPERATIONS

ELECTRONIC COMPUTER SERVICES

Introduction

Data processing activities have been unusually varied in the past year, partly because of the many different computing facilities available to us and partly because of the different levels of computer competence by individual members of the research staff.

Problems range from developing the use of our small in-house computer as a remote terminal to Columbia University's large 360/91, to advising research assistants on regression runs. Lora Weinstein's report on communications with Columbia's computer can be found below. Susan Crayne's synopsis of regression programs currently in use at the Bureau is available upon request.

The continuously increasing use of microdata sets and the consequent need for efficient handling of large data sets on magnetic tapes or disks require computer installations that can handle high-density tapes fast, inexpensively, and with a minimum of damage to tapes. Orin Hansen has been studying the relative merits of facilities at different university computer centers and commercial service bureau installations and the relative advantages of different computer languages in handling large data sets. He comments further on this work below. Documentation, always an important part of any data set, has become vital. Richard and Nancy Ruggles are working on the development of a system designed to make documentation machine readable, efficient, and, if possible, standardized.

The availability of our large time-series data bank has also had some consequences for data processing operations. We have been involved in the technical aspects of the data bank operations as well as in the use of the data bank by Bureau personnel. Since we agreed to provide the data base and current updates to all groups of ten or more users, for whatever time-sharing system they use, we needed to develop a procedure for efficient updating on several different time-sharing systems. As far as use by researchers is concerned, we have influenced the development and helped with the documentation of one of the "languages" used to access, manipulate and analyze time series (Rapidata's PLEA: Prototype Language for Economic Analysis). We have also converted some of our own programs, primarily those used in the analysis of current business conditions, to utilize the latest available information in the data bank.

The Bureau's development of a Center for Research in Computational Techniques and Management Sciences (see Sandford Berg's and Mark Eisner's report below) has not, as yet, affected our operations appreciably. We are, however, expecting to be involved in an exchange of skills and a pooling of algorithms, methods, and programs.

Charlotte Boschan

The Small Computer as a Remote Job Entry Device

One of the computers to which we have access is the IBM system 360/91 at the Columbia University Computer Center. In the past, access to this machine has been either by transportation of card input and subsequent output or by remote submittal from a terminal, the IBM 2741. The first way is slow and expensive, the second permits only a very limited amount of input and output, since the 2741 is essentially a typewriter.

We have now developed a means of using our in-house IBM 1130 as a remote job entry device. Input can be read from cards by the system 1130 card reader, and the job is transmitted over phone lines into the 360/91 job input stream. Input decks need not be changed for remote submittal. When the job is completed, the output can be received and printed on the system 1130 printer or punched on the card punch. Binary input and output can be transmitted.

There are, however, some disadvantages to this method of access. Transmission

depends upon the quality of the connection, and we are using regular voice-grade phone lines. Our 1130 has relatively slow input-output devices: (400 cards, 80 lines per minute.) While most input decks will be read reasonably quickly, large amounts of output could take hours to print. In such cases it is possible to direct all or part of the output to the 360/91 printer and have it returned by messenger.

While use of the 1130 as a remote job entry device is not the same as having a large computer in-house, we hope that it will prove to be more efficient than our old arrangement.

Lora Weinstein

Survey of Computing and Programming Systems

Electronic computation is playing an increasingly important role in economic research and consequently represents an increasing fraction of the Bureau's research budget. Cost and efficiency are determined in part by the characteristics of the operating systems used by different computing installations even on identical computers, and computing charges are determined in a variety of different ways and on the basis of different operational parameters. There is, hence, virtually no substitute for actually running comparable programs on the different machines involved. Consequently, a continuing series of comparisons is being carried out, using programs and statistical packages representative of the Bureau's work, to determine the optimum distribution of the Bureau's computing effort among the various facilities available.

A similar appraisal is being made of the relative advantages of some of the specialized computer languages that are now available. These languages permit the research worker to control the more common types of editing and manipulation of his data through the use of relatively simple instructions. Two of these languages, Datatext and SPSS (Statistical Package for the Social Sciences) have been found to be very useful for some of the Bureau's projects.

O. C. Hansen

Data Documentation Systems

The National Bureau is becoming increasingly involved in processing large data sets. Research is being undertaken on the development of machine readable documentation systems that can provide the basis for establishing a data library. These systems describe the organization and content of magnetic tape and disk files so that they can be accessed and operated on by standard programs. This work is complementary to the development of programs used to analyze data.

As a follow-up of the ad hoc Committee on Standardization of Procedures for Transferring Data Sets from One Institution to Another, which was created by the Inter-Institutional Conference on the Computer in Economic and Social Research, discussions are being held with the Urban Institute to see whether a format for documentation in machine readable form can be agreed upon. If this can be done, the proposed standards will be written up and circulated to a wider range of readers.

Richard Ruggles
Nancy D. Ruggles

NBER Data Bank

The National Bureau's machine readable time-series data bank now includes about 2500 series, 750 of which are annual, the rest quarterly and monthly. This bank is used by members of the Bureau's research staff as well as by outsiders. The use made by Bureau members has increased appreciably in the last year, as the number of available series has increased and the ease of access has improved. The number of outside users is now about fifty-eight, including three universities. These have access to the data bank through remote terminals, via a commercial time-sharing system. At present there are two user groups: one, the original Project Economics,

has access to the data bank through the Rapidata time-sharing system; the other uses General Electric's Information Management Analysis and Projection (MAP) system. Other users' groups will probably be organized around other time-sharing systems in the near future. Each individual user agrees to a set of terms of cooperation and, except for academic institutions, each participates in compensating the Bureau for a part of the cost of maintaining the bank.

Each of the series included in the bank has been chosen—by users' representatives and the NBER—for its general usefulness, and has been carefully checked for comparability over time. Source documentation is available both on line and in printed form. Seasonal and trading-day adjustments are constantly checked and a working relationship is maintained with many of the agencies issuing the statistics. Current updates and revisions are entered within forty-eight hours of their release; major revisions take up to one working week.

Responsibility for the data base is shared within the department. Hanna Stern supervises source documentation. Dorothy O'Brien's concern is with seasonal analysis and other checking. Constance Lim is in charge of the financial data, particularly the banking series. Nadeschda Bohsack works with the National Income and Product Accounts. Wan-Lee Hsu is primarily responsible for maintenance of the base on the GE system.

Charlotte Boschan
Peggy M. Cahn

Center for Research in Computational Techniques for Economics and Management Science

Within the last decade the high-speed digital computer has become an essential but expensive research tool in applied statistics and quantitative economics. Although the increased storage and computational ability has yielded significant benefits, the fast pace of change has inevitably caused serious dislocations. The costs of manipulating large data sets, the rapid turnover of computer hardware, and the duplication of programming efforts have resulted in relatively inefficient utilization of raw computer power. Such dislocations are, of course, a feature of any new technology, particularly one which is interdisciplinary in nature.

After a period of intensive experimentation with computer technology and its application to a wide range of research activities, researchers in quantitative economics can now consolidate and extend recent advances. The National Bureau is responding to this opportunity by establishing, with the support of the National Science Foundation, a Center for Research in Computational Techniques for Economics and Management Sciences. The Center is intended to assist the innovative researcher who will interact with a highly skilled staff of programmers and system analysts and a comprehensive computer operating system designed to facilitate the use of sophisticated techniques.

Researchers at the Center will explore both proven and new areas of quantitative techniques, with a view to determining their structure and the means of transforming them into computer algorithms. These endeavors should result in useful new software for a broad class of users. All software programs will be developed within the framework of an entire system, and the basic modules produced can be utilized in several related systems, thus reducing the duplication of effort. These programs will be disseminated through educational activities and maintenance procedures.

As conceived by its founders, the Center will permit research work to be done from diverse locations through the relatively new technology of interactive remote processing. The Center should significantly enrich research activity in the fields it covers and, it is hoped, may serve as a prototype for similar centers in other disciplines.

Sanford Berg
Mark Eisner

Research on Distributed Lags

My note "Comment on Zeckhauser and Thompson's Study of Non-Normality in Regression," pointing out the important connection between heteroscedasticity and non-normality in applied work, will be published in the *Review of Economics and Statistics*.

My research at the Bureau has revolved around the use of new techniques for estimation of distributed lag relations in a number of applied contexts. The two most important technical innovations are (a) a test for the existence of "feedback" or unidirectional causality in multivariate time-series models and (b) frequency-domain techniques for estimation of lag distributions. Both these techniques (especially the first) were developed as applied tools in the research for "Money, Income, and Causality," a paper presented to a Bureau seminar in November 1970 and now available in a revised and expanded version. The feedback analysis is being extended to models of factor demand at aggregate and industry levels. Attractive areas for future application are models of price/wage dynamics and (possibly) analysis of feedbacks between the aggregate economy and certain of its volatile or potentially exogenous components (e.g., construction or automobiles).

Frequency-domain estimation techniques are particularly convenient in feedback analysis, but they have other applications as well. One in which I am interested is the area of general autoregressive, multivariate aggregate models with a forecasting orientation. Choosing an appropriate specification in such models is a delicate problem, at present largely unexplored, and should be fertile ground for application of frequency-domain methods.

Development of computer programs for estimation and testing in the frequency domain has been an important part of my work. A flexible program for doing many types of frequency-domain work, using the Fast Fourier Transform, is now thoroughly debugged. Plans are to add to it a capability for computationally efficient multivariate distributed lag estimation.

Christopher Sims

Statistical and Economic Methodology

My activities listed in last year's *Annual Report* are still underway. My paper with Sidney Jacobs entitled "REGEN—Computer Program to Generate Multivariate Observations for Linear Regression Equations" has been reviewed by a staff reading committee, and is to be published in the National Bureau's new journal, *The Annals of Economic and Social Measurement*.

Yoel Haitovsky

Statistical Dependence in Prices and Interest Rates

In the 1970 *Annual Report* I described the main characteristics of R/S analysis¹, a technique for the study of nonperiodic long-run statistical dependence in time series. I am in the process of applying this technique to certain historical price and interest rate records in the NBER and other data libraries.

The behavior of competitive prices is mainly studied to determine to what extent a knowledge of the past can help predict something about the future. Why the question interests speculators is obvious. Economists are interested because active competitive markets may be expected to come close to the ideal of "efficiency," i.e., a market is said to be efficient if every temporal disequilibrium large enough to allow profits that exceed brokerage fees on the average is promptly arbitrated out of existence. If brokerage fees are neglected, the expected profit vanishes, and mathematicians say that price follows a "martingale" process. The classical "random walk" process, which postulates that price changes over nonoverlapping time intervals are independent, is the best-known special martingale. But in the

¹ R/S = cumulative range divided by the standard deviation.

presence of positive brokerage fees and interest rates the martingale is *not* a full model of efficiency.

In two earlier articles I investigated how market efficiency can actually be attained or approximated. One conclusion was that, if the "trends" in nonarbitrated prices are very persistent, then the best conceivable arbitrage must leave a certain amount of persistence. This complicates further the formal characterization of an efficient market.

As to the empirical aspects, past investigations disagree even on the basic issue of whether dependence vanishes, is positive, or is negative. But in fact none of those investigations was believable, because they all used statistical tools that imply that the process ruling price is near Gaussian. In reality, the variances of competitive price-change distributions are for practical purposes infinite. Therefore, the classical statistical tools may well be inapplicable.

The new statistical technique "R/S analysis" seems very promising in this connection. Practically all independent random processes and a variety of martingales I have spot-checked behave identically from the viewpoint of R/S, so they can be called "R/S independent." The concept of R/S independence is thus robust with respect to infinite variance. In the case of price changes, it can serve as a useful surrogate for martingale behavior, i.e., for market efficiency in the absence of brokerage fees. Other processes are either short-run or long-run R/S dependent and the intensity of long-run R/S dependence can ordinarily be measured by a single parameter $H = 0.5$, with H called the exponent.

So far I have R/S-analyzed various interest rate series from Macaulay, prices of commodities from various sources, and series of daily and monthly returns on securities. I have found that different kinds of "price" series fall in different categories.

Certain prices, including those of call money, exhibit strong persistence; say, an intensity of $H = 0.7$. This was to be expected, because call money is a tool of arbitrage, so its price cannot itself be arbitrated; its behavior should follow closely that of the various exogenous economic quantities. There is strong evidence that economic time series other than price changes and various physical (e.g., climatic) triggers of the economy are strongly persistent, so the observed behavior of call money rates was as expected.

At the other extreme, certain prices, including those of British Consols, cash wheat, and some securities, have R/S independent increments. The reason for this is unclear. They are possibly dominated by what may be called "market noise." Spot commodity prices are not subject to thorough arbitrage, however, so the absence of persistence in wheat is something of a puzzle. Explanation may be sought in institutional features; the arbitrage that is present in future prices may have an indirect effect on spot prices.

The intermediate cases are those where there is a slight dependence. These include prices of spot cotton and many securities. Going deeper, I have found in many instances that the observed R/S dependence is wholly due to small price changes, which are both more difficult and less worthwhile to arbitrage; large changes are practically R/S independent, even though the moments when they occur are highly nonindependent (clustered). But this and other results I obtained leave many issues open. In particular, is or is not the actually observed dependence precisely compatible with efficiency, and why are there so many differences between different series, including cases in which the dependence is negligible?

Benoit B. Mandelbrot

Welfare Change Measurement

Since Jules Dupuit's fundamental contributions in the 1840's, economists have attempted to measure allocational inefficiency. I have completed a study, "The Theory and Application of Welfare Cost Measurement," which provides a reason-

ably precise and comprehensive statement of the central ideas and techniques that underlie current welfare change measurement and makes a few modest extensions.

The welfare change in going from one alternative to another by a person with consistent preferences is essentially measured by the distance between the indifference surfaces on which the alternatives lie (sometimes depending specifically on one of the alternatives). In applications, one must infer these preferences from demand functions in order to measure this distance. The paper discusses how this is done, taking income effects explicitly into account when relevant. Next, the problems that arise when many individuals are present are considered. Unless there is a consistent framework for evaluating the distribution of income, it seems best to consider that the measurement only reflects *potential* welfare change. Finally, the more difficult problem of intertemporal welfare change is considered briefly, and the rationale and pitfalls of one important measure are discussed.

John C. Hause